LEARNING THROUGH LISTENING. FINAL REPORT.

By

Edward S. Cobb

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ABSTRACT

This final evaluation report covers five funding periods under which the Learning Through Listening project received support from the Division of Continuing Education(NYSED). The first period began in January, 1976 and the fifth period ended in February, 1981. In the interim, there were three occasions upon which funding was terminated temporarily. The cumulative period without support was eighteen months.

Our long-term goal has always been directed toward research which could alleviate the problem of learning through listening for blind students -- or more specifically, research which would make independent study by tape recorder less difficult. The difficulty, if not fully appreciated in the past, has at least always been recognized as a problem blind students must contend with, and our objectives in the first funding period were directed toward attacking it as has always been done, by developing a "how-to-listen-better" course.

By the start of the second funding period, we had abandoned that solution in favor of an entirely new approach which rested upon the assumption that changing the tape presentation structure could make aural study with a tape recorder easier. To check that idea out, we built a laboratory by which we could engage in the study of study (SOS) on tape recorders. Each of five study stations were interfaced to an on-line computer which monitored all subject-initiated operations of the play-back decks, and the tape locations at which they occurred. Over a two-year period, we conducted research in the new aural learning laboratory which provided study activity data which would, eventually, allow us to describe the study performances of blind adults who were paid to serve as subjects in our experiments. In that time, 16 subjects learned various course areas at the high school level from tape presentation structures which were systematically changed as independent variables within our experimental designs. We collected computer-stored study activity data over the course of thousands of hours of study time. During that two-year period of data acquisition, however, none of those data were analyzed because of a lack of a computer program to do that job.

In our last experiment(Exp. III), we contrasted study performance with two tape presentation structures: the literal transcription (LT) tape -- which is the kind of tape structure currently available to blind students -- and the adaptation structure (AS) tape -- which is the kind of tape we developed to alleviate the problem of aural study. Two subjects were used in that experiment, each of whom served as his own control, and the experiment ran for the four months which was the duration of the forth funding period. We were without funding support for the next fourteen months, after which we received support for a fifth funding period. The objectives for that period were to develop computer programs and use them to analyze the study activity data which had been collected.

The results of the data analysis support, unequivocally, two conclusions. The first concerns the magnitude of the problem blind students face while engaged in independent study with LT tapes. In comparison to a sighted student studying from a textbook, the aural learner is at a very severe disadvantage on many fronts. Study interactions take much more time(perhaps 10 to 20 times as much), and because of that very frustrating and unrewarding problem, there is a strong tendency to study passively with LT tapes. Passive study involves listening to large amounts of material at a time without interacting with it(e.g., play durations of greater than one-half hour).

The other main result of our data analysis represents a very significant break-through in the education of the blind. Our results show that AS tapes greatly reduce the problems encountered while studying from LT tapes. That is mainly because the approximate location of target material is always known, and almost always is just a short tape distance away, making study interactions practical.

The durations of searching interactions seldom exceed a few seconds (in contrast to several minutes for search-return cycles with LT tapes).

Thus our data analysis strongly supports the principle of making structural adaptations in educational presentations to be learned by tape recorder. The adaptations we have developed are but a beginning toward what can be done to facilitate aural study. They are a substantial beginning, however, and the adaptation structure can be used to **excellant** benefit just as it is. Thus we recommend that support be given for the writing of educational materials appropriate to that structure immediately.

Our initial use of the SOS research tool has provided data which show that it is not limited to yielding benefits to the blind. It is an innovation which has significant implications for education in general, and at all levels. Two of those implications are briefly discussed at the end of this report. One concerns a new method by which educational materials (to be studied by either reading or listening) may be reliably improved upon. The method is called the automatic editor because content areas in a text which generate confusion during independent study can be recognized by a special computer program.

The other application of the SOS research tool is to the measurement of individual differences between students (i.e., testing). Specifically, study activity data have the potential of providing indices of student comprehension and ability which are far more reliable than traditional test-score measures.

I INTRODUCTION

This interim report covers the fifth funding period for the *Learning Through Listening* (LTL) project. The funding period was for thirteen months (February 1, 1980 to February 28, 1981), and the purpose of the funding was to analyze computer-stored data on how blind subjects operate tape recorders during independent study of high-school level aural presentations. The data were collected over a two year period (November 1976 to November 1978) from 16 visually impaired adults who served as experimental subjects for varying periods of time (see Table 1, Section I). The data constitute detailed records representing many thousands of hours of study time.

Because this report is also the last interim report for the LTL project (i.e., further funding for this research is no longer available from the Bureau of Basic Continuing Education, N.Y.S.E.D.), a brief, general overview of the five-year research effort is appropriate here, after which the specific activities and results of the fifth funding period will be considered. For those who are interested in a more detailed account for each of the successive funding periods, the appropriate interim reports are on file with the funding agency. Those reports, as well as reprints of our four publications, and other related project materials, may also be obtained from the LTL Director:

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Overview of the LTL Project

Our research has addressed a major problem which blind students in general must contend with: the problem of studying school assignments from tape recordings which are literal transcriptions of the textbooks studied by their sighted peers. That problem is not a small one. It is one area of education in which blind students are at a serious disadvantage.

There are many reasons why that is so (Cobb, 1978), all of which concern the fact that the student who must study from a tape recording has *less control over the presentation to be learned* than the student who is studying the same material by reading it. What does that mean, *less control*? Well, let's consider one obvious example of the difference between reading from a printed school assignment and independent study by listening to a literal transcription of that assignment. Our example concerns a difference in what we will call the *momentary availability* of the content during study. Sighted students can think about what they are reading *while* the material they are thinking about is readily available (e.g., on the same page the student is reading from) for selective re-reading. In contrast, aural learners are more restricted: they think about whatever they are able to remember of what they *just heard*. Thus, during study interaction, aural learners are forced to rely much more heavily upon short-term memory, which can be easily overloaded. That is one of many differences between aural and visual study which make the former a *problem* relative to the latter.

Finding more remote material for re-listening -- a very necessary activity for successful study of unfamiliar (sic) subject matter -- is another aspect of the problem of studying from a tape. The sighted student is generally only seconds away from locating a passage, even if it was read over an hour before. When studying with a literal transcription (LT) tape, however, our research has shown that the blind student very often spends on the order of several *minutes* searching for target content which was heard not long before.

Once target content has been located, is there still a big difference in the ways in which readers and listeners can control the presentation? Quite definitely. A sighted student can interact with the material *selectively*, for the eyes can

quickly scan during re-reading, discarding that which is well understood in favor of particulars requiring further thought. In contrast, the visually imparired student, having finally found a passage for re-listening, usually listens to all of it, for there is no practical way of isolating that which requires further attention from that which does not.

The inefficiency of non-selective re-listening is greatly magnified during independent study in preparation for an examination. While sighted students are exercising their option to ignore the greater portion of study material (concentrating instead on key concepts, and on that which still remains unclear), our research(see Section IV) has shown that the blind student will typically "review" for an examination by re-listening to the content of an LT tape in its entirety. That is because, with LT tapes, there is simply no practical way of listening to them selectively. It is clear that a great deal of time is wasted with non-selective study in review for tests.

The three kinds of differences in study options which we have mentioned so far -- momentary availability, finding (or searching) for target material, and selective re-listening -- are all related to the general problem of less student control over the presentation to be learned because they all relate to content accessibility. The student who is a reader can do things during independent study(i.e., exert control) which allow for much greater accessibility than is the case for the aural learner.

We have only sampled the problem of listening to a tape recording. There are many other differences between studying by reading and studying by listening which put visually impaired students at a severe disadvantage when they must compete in an educational setting with sighted students (Cobb, 1977). How well are blind students able to compete with their sighted peers, in high school, for example? According to several published statistical reports (for a summary, see Cobb, 1976) on diploma achievement and high school drop-out rates, a

relatively low percent of the population of blind students entering high school ever graduate. Indeed, one study showed most blind students dropping out by the tenth grade, with less than five percent of those entering high school obtaining a diploma (Statistical Abstract of the U. S., in Cobb, 1976). That, of course, means a very low percentage of blind adults with a high school education because very few of the blind avail themselves of the G. E. D. option. And that becomes an additional handicap for the blind when seeking employment.

Certainly the blind student is at a disadvantage on many fronts, whether in high school or in a continuing education program. Recent legislation (Section 504 of the Federal Handicapped Law) points to many inadequacies in the procedures and physical facilities of educational institutions. Compliance requirements are designed to alleviate and/or compensate for those disadvantages, thus allowing blind students (for example) a fairer chance for successful completion of educational programs. That legislation, however, is addressed to only a small part of what constitutes the educational disadvantage faced by blind students. It does nothing to reduce, or compensate for, the difficulties blind students experience while trying to do independent study of school assignments. As all students progress through school, the means by which knowledge is acquired shifts increasingly to a greater and greater reliance upon independent study. Thus the ability to engage in efficient independent study is especially important to success in continuing education. Certainly from high school on, a great deal of what students are expected to learn depends upon the completion of homework assignments, and upon how well they are able to prepare for their examinations. Could it be that the high drop-out rate from high school is related to this increasing requirement for independent study? And what about the fact that so few of the blind who have dropped out ever reach the point where they even attempt to take an examination for the G.E.D? Is that because independent preparation is so difficult? Our data analyses on how blind adults study from different kinds of taped presentation structures offer an objective basis for answering those questions with a resounding YES!

We need not belabor the point here that the blind are at a disadvantage during independent aural study, for the "problem of listening" for the visually impaired has hardly gone unrecognized, in spite of the fact that the data from the Learning Through Listening research laboratory seem to be the first empirical demonstration of that problem. Indeed, there is a substantial research literature which is specifically addressed to the issue of how to compensate for these difficulties (for recent reviews of that literature see Cobb, 1976; Doughterty, 1974; or Duker, 1968). Most of the past efforts at compensating for the problem of listening have assumed that the solution rests somehow in teaching the blind student to be a better listener. Indeed, the original proposal for the LTL project, written in the summer of 1975, was built around that assumption.

Thus the major thrust of many programs has been to develop and/or validate materials to be used in "how-to-listen-better" courses. But there are several reasons to question the notion that "better listening ability" is a helpful approach to take, reasons which are discussed at length in Cobb (1977).

Early in 1976, we abandoned the original conception for LTL in favor of an entirely different approach to the problems encountered when learning with a tape recorder. Rather than trying to make "better listeners" out of a sample of blind students in the belief that those particular students would then be able to cope with the special difficulties inherent in studying from LT tapes, we decided to change the tape recording structure itself so that, quite simply, the special difficulties were not as troublesome for any student using the new tape structure. The idea from the start was that it would be possible to alter the standard LT presentation structure so that the blind student could more nearly approximate the range of interaction options with study materials which is enjoyed by sighted students during visual study.

Thus, implicit in our new approach to the problem of listening has been a key assumption: the structure which has evolved (quite obviously to the benefit of the sighted) for presenting printed matter for reading is not at all an optimal structure for aural study by tape recorder. It is an obvious assumption to make when you stop to think about it, for the structural properties which facilitate the reading of print would, quite predictably, have evolved as visual (not auditory) stimuli. Most of those visual properties have no auditory analogue on an LT tape recording. For example, the kinds of ways that printed material is segregated (e.g., into paragraphs), or in other ways made visually conspicuous (e.g., different print sizes and styles), are for the most part lost during the transcription process.

Early in our research, we saw several ways in which certain changes in the tape recording structure would compensate for the loss of visual structure which occured in transcription from print to tape. To begin with, it was obvious that searching for a target passage (perhaps made visually conspicuous with bold-faced type at the start of a paragraph) by turning pages and looking is a study activity which is a great deal more efficient than searching for the same verbal particular by using the fastfoward, rewind, play and stop buttons on a tape recorder while listening. What is the difference in efficiency? Well, if you allow a sighted student ten seconds to find that paragraph beginning with bold-faced print, six pages away, our data on how blind subjects interact with the LT tape structure show that 300 seconds of search time by a highly experienced tape recorder operator would not be atypical for that task. That is, the two modes of independent study (text book vs LT tape of the text book) may differ in their efficiency by a factor of 30 or more with respect to just one of the many activities which are necessary for effective independent study:

searching for target material.

When we try to teach some blind students to be "better listeners" we are not addressing ourselves to the kind of disadvantage described above. Such programs are, for the most part, dealing with a different kind of problem -- the problem of language comprehension (not listening, per se), a problem that all students have, whether they are reading or listening. Teaching students so-called "listening skills" will certainly help them to comprehend the language recorded on an LT tape (just as those same skills will be of benefit to the sighted student who is reading the same material from which the LT tape was made), but they have little to do with the disadvantages of studying by tape recorder. For example, one cannot comprehend material if it cannot be found!

Once we made the assumption that the structure and content of a presentation for aural study could be changed (i.e., adapted) to conform to the needs and limitations of a listener with a tape recorder (not a reader with a book), the possibilities for improvement became clearer. For example, going back to the problem of search time, if hunting through pages is so much more practical than hunting through tape, then an obvious attack upon that problem would be to adapt the aural presentation structure so that the blind student has less tape to hunt through. And one way to do that is to segregate the content onto two concurrently-running tape tracks (referred to as Channels A and B in our aural adaptation structure, described below). Thus, if an LT tape recording is 8000 cm long, by segregating the content onto two tape tracks of 4000 cm each, the amount of tape to hunt through has, right off, been reduced by 50%, provided the student always knows what content is on each tape track. In developing our special adaptation structure (AS) tapes, we confronted the problem of informing the student of where different kinds of content are located in several ways, as outlined below. For a more complete description of our adaptation structure and several of its advantages, see Cobb (1978, 1977).

The Aural Adaptation Structure. Going through a typical textbook, one can easily see that its verbal contents are segregated into categories: the *narrative*; short, discrete items like summary statements which are designed to help students during *review* study; and *question* items which the student ought to be able to answer if the narrative and review material have been understood. In most textbooks, the review and question items occur at the end of chapters, and sometimes the chapter narrative is preceded by a short section which describes the *contents* of the chapter. Thus the material of a textbook chapter is already segregated into categories by the author: contents, narrative, review and questions.

With a little deliberation on the part of the reader, the narrative material itself can be sub-divided into two types, which we call the *exposition* and *commentary*. Here, the differences are more difficult to define, but still quite detectable with practice. Quoting a small part of a published description of AS tapes (Cobb, 1978) will provide a general idea of *some* of the more important classification criteria:

> ". . .the function of the exposition is different from that of the commentary. The former is introductory and more generic; the latter is explanatory and more specific. The exposition contains the "core" of the (narrative) content; for example, the presentation of a new word and its relation to three other words that the student has already come across.
>
> "The commentary . . . is always *about* the exposition. It is a development that contains examples, expressions of, and other relations to the points made in the exposition (i.e., background information)."

In the case of our development of the adaptation structure for aural study, we wrote ("from scratch") all materials for it, rather than re-arranging the contents of an already-published textbook, for there are several other kinds of changes designed to facilitate aural learning -- changes which cannot be implemented in any practical way by *selecting from* the contents of a textbook.

And, still other properties of the adaptation structure represent additions to what is generally found in textbook materials.

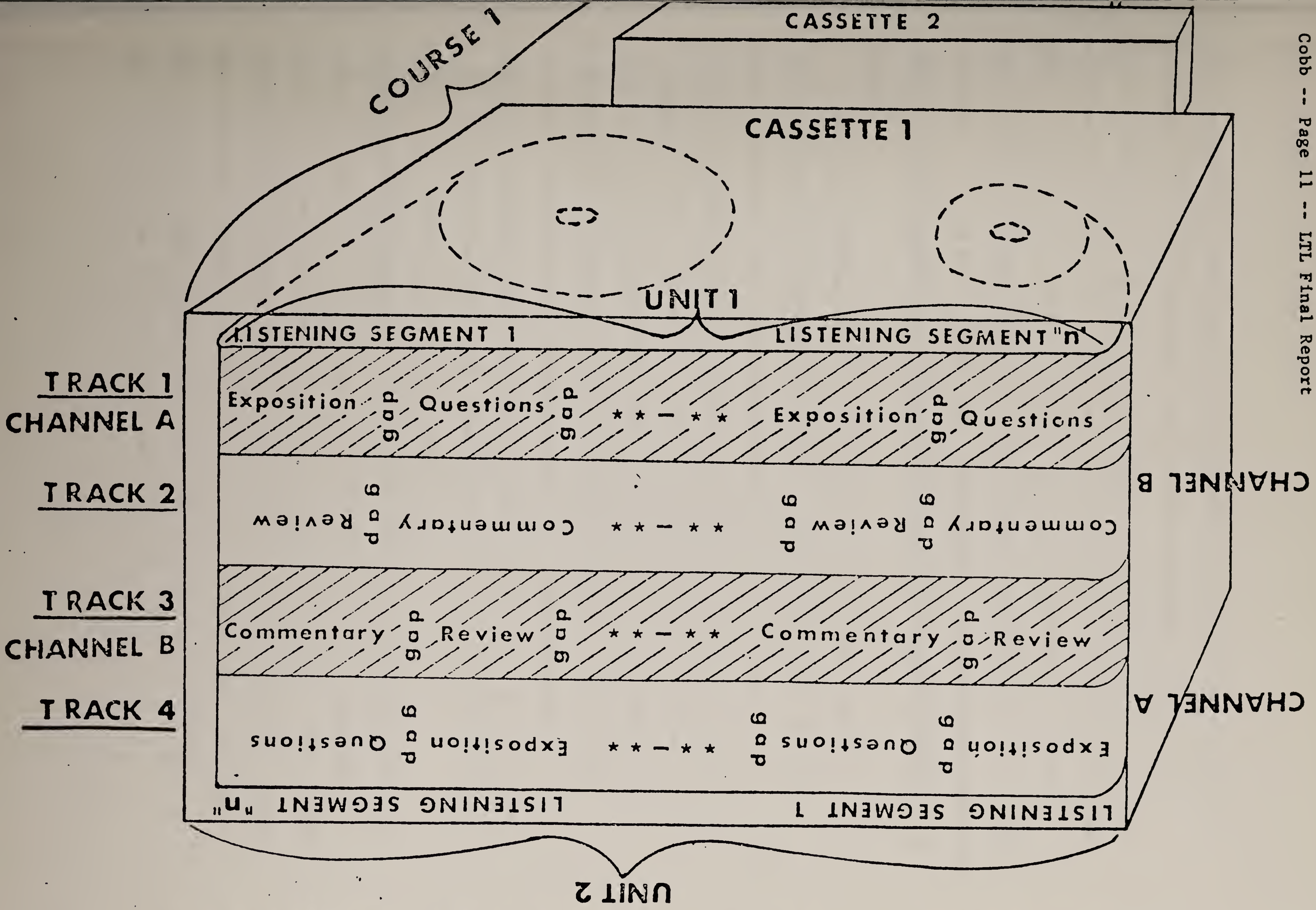
However classification is arrived at, textbook material can be arranged into four major categories: expository, commentary, review and questions. Using a small amount of material corresponding to each of those four categories (one of our experiments addressed the question of how small), we arrive at the basic unit of the aural adaptation structure: the listening segment (LS). Figure 1 shows the spatial arrangement of the four LS parts on two concurrent tape tracks. For each LS in a unit, Channel A always contains the expository and interrogatory content, while the commentary and review are LS parts which are always found on Channel B. The sequence of information which is established on Channel A (in the exposition) is always preserved in the other three LS parts. In addition, the numbered items in the review and question parts are well correlated with each other, and they are lettered to indicate which of the LS narrative parts they reference.

A "unit" of a course (in our research, generally a 50 to 60 min recording) always begins with a contents segment (with different kinds of contents information recorded on the two channels) and ends with a summary segment, which represents a third type of condensed information. (Neither of these segments is shown in Fig. 1, but they are part of the representation of AS tapes seen in Fig. , Section IV). The number of LS's in a unit is, of course, determined by the mean LS length. In one of our experiments (described in Section IV), the narrative parts ranged from three to five minutes (at normal play speed), while question and review parts were approximately one-half to one-third of that length.

In Fig. 1, the word "gap" between LS's and LS parts indicates high frequency code signals by which students can identify the LS number or LS part within the unit they are studying. Using the knowledge of the adaptation structure so far described, and the code system of high-frequency index tones which are

Figure Legend

Figure 1. Parts of the adaptation structure for aural study are shown. Courses are tape recorded on cassettes. Each side of a cassette is a unit (50 to 60 min recording). Material in each unit is divided into listening segments (LS's) and each LS is recorded on two tape tracks, Channels A and B, which run concurrently (i.e., either one may be accessed by the student at any time). There are four main parts to each LS: exposition and questions (Channel A), and commentary and review (Channel B). Not shown in this figure are the contents segment and the summary segment which begin and end each AS unit respectively.


COURSE 1
CASSETTE 2
CASSETTE 1
UNIT 1
LISTENING SEGMENT 1
LISTENING SEGMENT "n"
TRACK 1
CHANNEL A
Exposition gap Questions gap * * — * * Exposition gap Questions
TRACK 2
Commentary gap Review * * — * * Commentary gap Review gap
CHANNEL B
TRACK 3
CHANNEL B
Commentary gap Review gap * * — * * Commentary gap Review
TRACK 4
Exposition gap Questions * * — * * Exposition gap Questions gap
CHANNEL A
LISTENING SEGMENT 1
LISTENING SEGMENT "n"
UNIT 2

LEARNING THROUGH LISTENING FORMAT

audible only in the fast forward and rewind modes, an experienced student who is stduying LS #5 can, for example, easily (within seconds) access material from the commentary of LS #2. With an LT tape of the same material, a comparable search and location would take several minutes (examples of which are shown in Section IV). So that is one of the great advantages of the adaptation structure: it allows the aural learner greater accessibility to the content of the tape. Or, to put it another way, with AS tapes, the student has much more control over the presentation being studied than is the case when studying from LT tapes.

As we have indicated, there are several properties of the adaptation structure which are not represented in Fig. 1, some of which have not even been mentioned here (for a more complete description of AS tapes, see Cobb, 1978). The above information should, however, provide enough of a basis to appreciate the concept of aural adaptation: a change in the spatial distribution of verbal content on a tape recording which allows a blind student to approximate the study-interaction options enjoyed by the sighted student). What we have said should also suffice for an appreciation of the basic rationale of the experimental procedure which generated the study activity data of the research we are reporting on in Section IV, research which was specifically designed to compare study with AS tapes vs study with LT tapes.

The Aural Learning Laboratory. The essential features of the aural adaptation structure described in the previous section had been arrived at logically. That is, the structure was not the product of empirical research. Once we had decided upon the listening segment as the basic unit of that structure, however, questions which required an empirical approach for answers were compelling: what do blind students do when they study from LT tapes? how is the study of AS tapes different? how long should LS's be? and so on.

These and similar kinds of questions could not be answered with logic since they all required empirical data obtained under the controlled conditions of a laboratory according to experimental designs. Accordingly, we built a laboratory by which we could record precisely how blind subjects interact with various kinds of tape recorded presentations.

The aural learning laboratory became operational in January 1977. It consists of two rooms, one with five student stations for studying by listening, and the other room for recording and analyzing study activity events. Each student station contains a standard play-back deck used by blind students (it is distributed by the American Printing House for the Blind). The APH tape recorders were modified so that all student-operated buttons caused electrical signals to be recorded in the memory of the computer located in the second room of the laboratory. Figure 2 is a photograph of a modified APH tape recorder with an electrical cable leading out from the back of it.

The cables from each of the five modified APH tape recorders are interfaced to an on-line computer(Data General 1230 Nova Series). In addition to continuously monitoring the time of occurrence of five study activity events (play, stop, forward, rewind, and track change), the tape locations at which those events occur are also recorded. From such raw data we could construct a complete record of how each of five concurrently studying subjects interacted with entire tapes as well as detailed parts of tapes.

There are many other features of the hardware system which were available at the start of our research which may be seen from an inspection of the block diagram of student stations and the computer control room shown in Fig. 3. Since 1977, the laboratory hardware capability has been increased in several important ways. Figures 4 and 5 are recent photographs of the aural study room and the computer control room respectively. For a more detailed description of the aural learning laboratory, see Perera and Cobb (1978).

Figure Legend

Figure 2. Modified playback machine used for aural study by subjects in LTL experimental research. The machine, made by General Electric company and distributed by the American Printing House for the Blind(Model No. 5192), is a cassette tape recorder manufactured especially for the visually impaired to use for general purpose recording and playback, and to reproduce "talking books." Five of these machines were modified to put out electrical signals for all student-operated functions(play, stop, forward, rewind and track switches). The cable interfaced to the computer in the other laboratory room can be seen at the rear of the photograph.

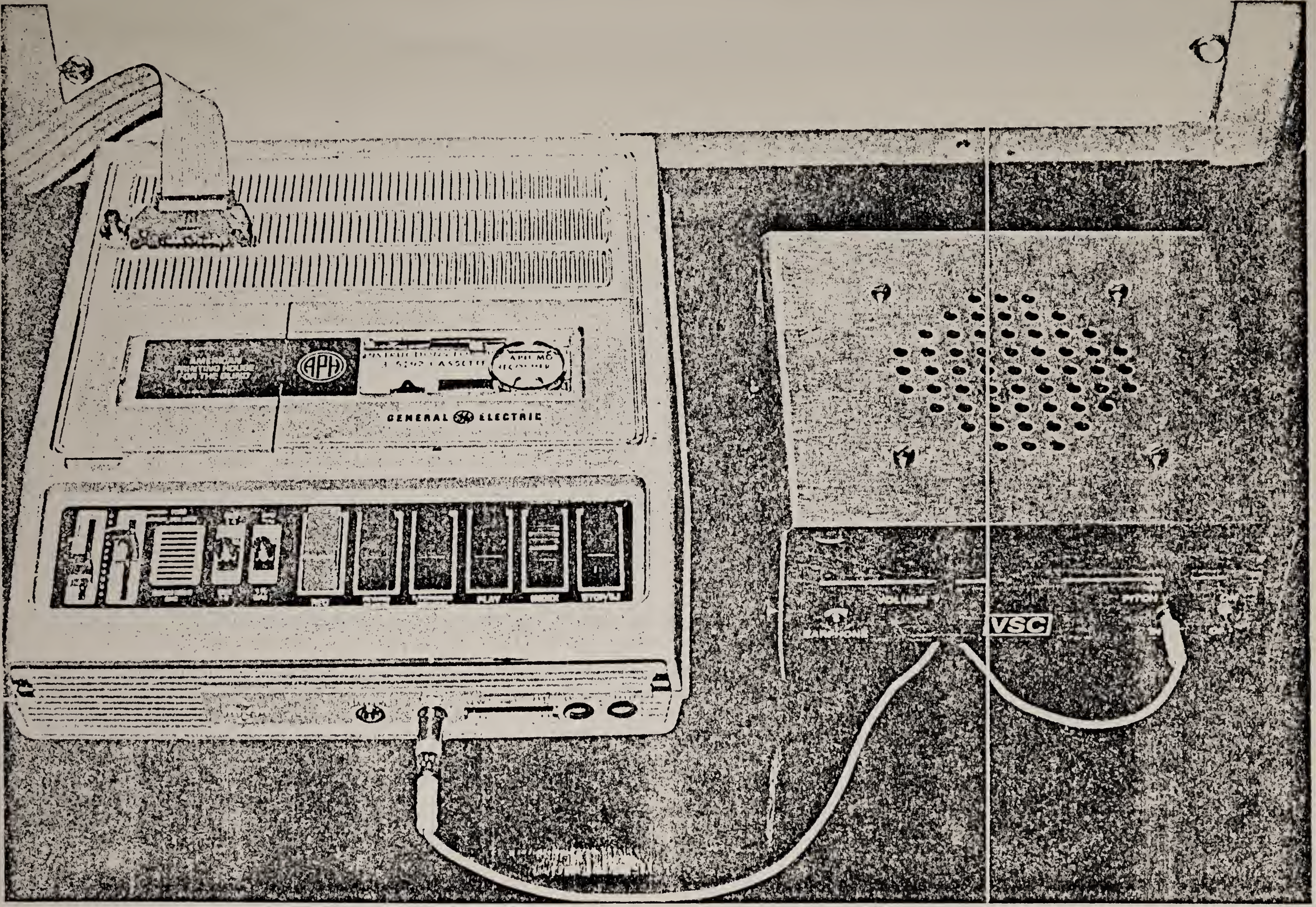

AMERICAN PRINTING HOUSE FOR THE BLIND
APH
GENERAL ELECTRIC
PLAY
INDEX
STOP/EJ
EARPHONE
VOLUME
VSC
PITCH

Figure Legend

Figure 3. Block diagram of the five student stations in the aural study room of the laboratory and the computer control room. Each of the student stations contains a modified playback machine with interface to the computer; earphone adapter; and interface to intercom. The response recorder was used by subjects to answer questions during study and examination periods, as well as for comments on the effectiveness of variations in the tape recorded presentations which were provided for study. Not shown in this diagram are several recent hardware additions. In particular, a H/P Graphics Plotter and a CRT terminal.

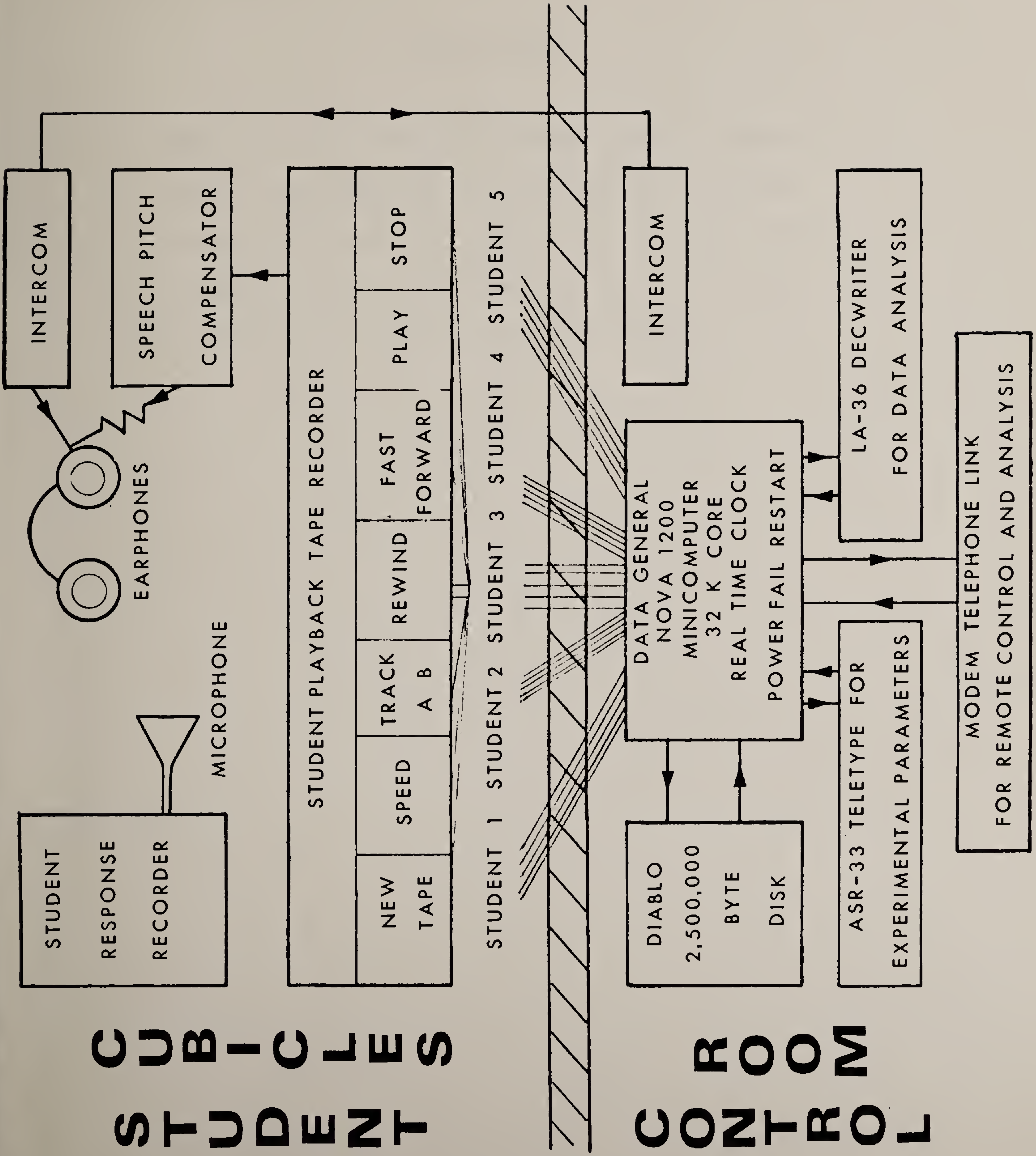

STUDENT CUBICLES
CONTROL ROOM
STUDENT RESPONSE RECORDER
MICROPHONE
EARPHONES
INTERCOM
SPEECH PITCH COMPENSATOR
STUDENT PLAYBACK TAPE RECORDER
NEW TAPE
SPEED
TRACK A B
REWIND
FAST FORWARD
PLAY
STOP
STUDENT 1
STUDENT 2
STUDENT 3
STUDENT 4
STUDENT 5
INTERCOM
DIABLO 2,500,000 BYTE DISK
DATA GENERAL NOVA 1200 MINICOMPUTER 32 K CORE REAL TIME CLOCK POWER FAIL RESTART
ASR-33 TELETYPE FOR EXPERIMENTAL PARAMETERS
LA-36 DECWRITER FOR DATA ANALYSIS
MODEM TELEPHONE LINK FOR REMOTE CONTROL AND ANALYSIS

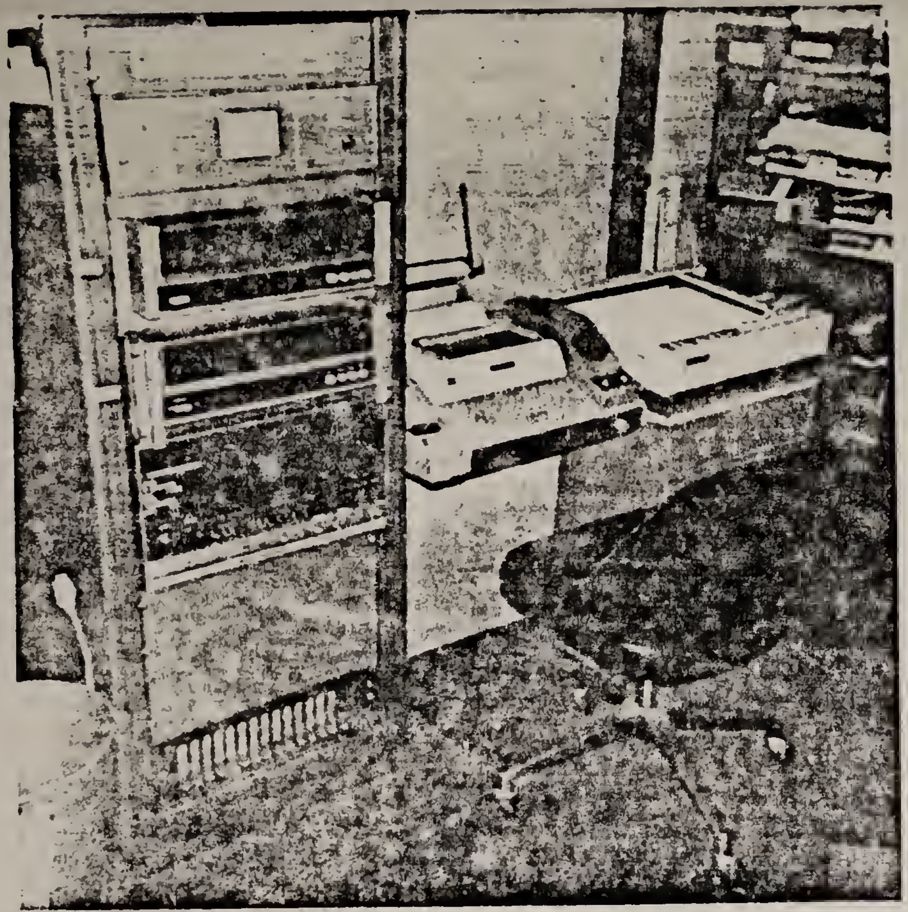
Figure Legend

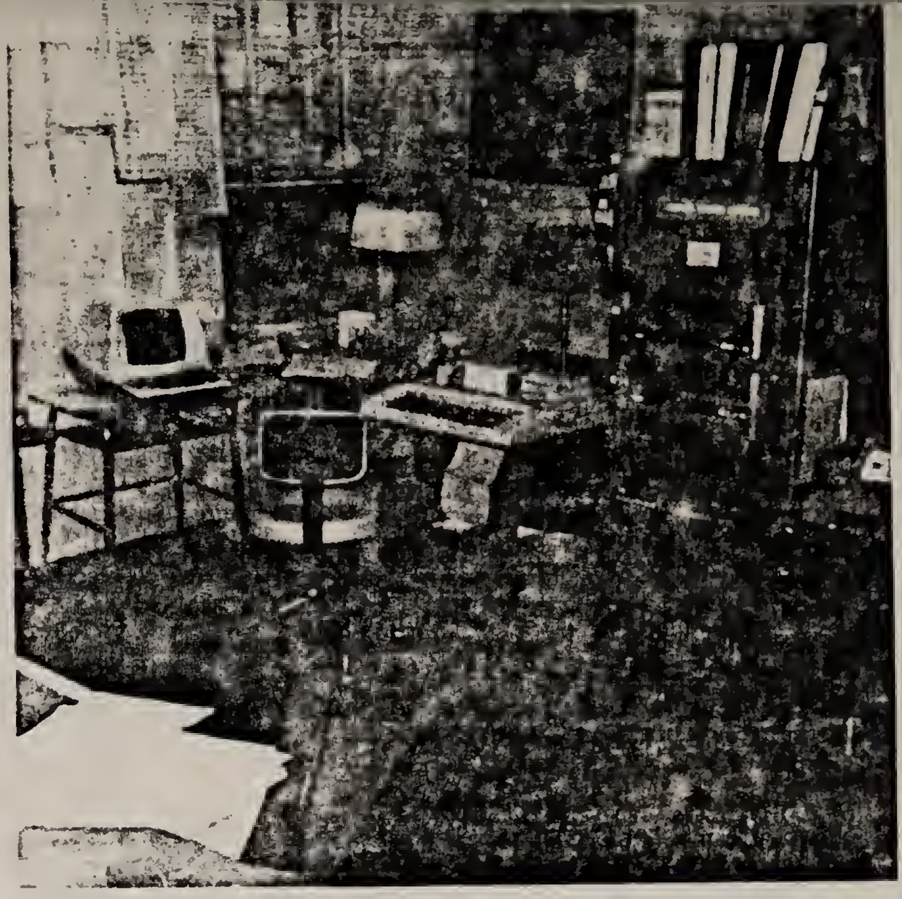
Figure 4. Aural study room showing visually impaired subject participating in an experiment on learning through listening. The subjects were all adult, high-school drop-outs who were paid to learn experimental materials tape recorded in different formats.

Fig. m

Figure Legend

Figure 5. Computer control room of the aural learning laboratory. The computer is a Data General 1230 Nova central processor with 32 K word core memory and real-time clock. It is interfaced to two 2.5 million-word capacity Diablo 4047A disk drives. A teletype Corporation ASR-33 teleprinter provides data output and communication between the operator and the data-acquisition program. An LA-36 Decwriter provides data analysis at 300 baud. A modem allows data to be accessed from remote locations over telephone lines. A CRT terminal and a H/P graphics plotter are also shown.





The Aural Learning System and the Pilot Research Phase. For two years, the LTL project was funded to obtain data on the study activities of blind adults interacting with specially-prepared tape recorded materials. Table 1 shows that a total of 16 subjects participated in the program for a range of from 2 to 24 months. For each subject, Table 1 shows entry and exit dates; the number of months of attendance in the third (7/77 -- 6/78) and fourth (7/78 -- 10/78) funding periods; the total number of months of attendance; the number of units of study materials completed; and the rates (in units per month) at which they were completed.

For the most part, our subjects were obtained from the New York Association for the Blind ("Lighthouse"). All 16 of them were high school drop-outs who ranged from 22 to 55 years of age. None could read print, and the durations of their visual impairments ranged from congenital blindness to normal vision a few years prior to participation in the LTL program. The subjects received no academic credit for learning through listening, but all were paid a stipend (the minimum wage) for the number of hours they worked each month. Regular attendance ranged from a minimum of three hours per week to as much as 20 hours per week.

Our research with these 16 subjects consisted of three distinct phases which we have designated as: pilot research; Experiment I; and Experiment III.* Since, in Section IV of this report, we are presenting data for Experiment III only, we will provide the procedural details for that experiment in that section. We will provide a general description of all three research phases here.

All the learning materials for the three research phases were written and recorded especially for the project's experimental purposes. All course units

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*Note: Experiment II was conducted under a different grant funded by a different agency.

Table 1

Student/Subject Attendance and Progress through the Units of Experiments I and III.

Student/ Subject Ident.		ATTENDANCE IN THE PROGRAM					NUMBER UNITS COMPLETED			PROGRESS Uts./Mo.		
No.	Name	Stud. Entr. Date	Stud. Exit Date	No. of Months 3rd Per.	4th Per.	Tot. Time	3rd Per.	4th Per.	Tot. Uts.	2nd Per.	3rd Per.	4th Per.
1	Lulu	11/76	2/78	8	--	16.0	4	--	14.0	1.25	0.50	--
2	Charles	11/76	10/78	12	1.0	21.0	9	2.8	21.8	1.25	0.75	2.80
5	Manuel	1/77	10/78	12	0.5	18.5	11	1.0*	22.0	1.67	0.92	2.00*
9	Cynthia	3/77	1/78	7	--	11.0	6	--	11.0	1.25	0.86	--
11	Maryanne	3/77	5/77	--	--	3.0	--	--	5.0	1.67	--	--
12	Lucina	3/77	2/78	8	--	12.0	3	--	12.0	2.25	0.38	--
15	Gary	3/77	8/78	12	0.5	16.5	11	1.0*	22.0	2.50	0.92	2.00*
17	Walter	4/77	8/78	12	1.0	16.0	10	1.0	13.0	0.67	0.83	1.00
18	George**	4/77	10/78	10	1.0	14.0	13	3.0*	22.0	2.00	1.30	3.00*
19	Pete	5/77	6/78	12	--	14.0	9	--	12.0	1.50	0.83	--
20	Sammella	10/77	5/78	8	--	8.0	9	--	9.0	--	1.12	--
21	Delores	10/77	5/78	8	--	8.0	22	--	22.0	--	2.75	--
16	Madeline	12/77	10/78	7	3.0	10.0	14	7.8	21.8	--	2.00	2.60
25	Edford	5/78	10/78	2	4.0	5.0	3	12.0*	15.0	--	1.50	3.00*
26	Chandra	5/78	10/78	2	4.0	5.0	2	13.0*	15.0	--	1.00	3.25*
27	Donald	5/78	7/78	2	0.5	2.5	2	1.0	3.0	--	1.00	2.00
Total: 16				122	15.5	180.5	128	42.6	240.6	16.01	7.29 ***	21.65
Mean:				8.1	1.72	11.28	8.5	4.7	15.0	1.60	0.81	2.41

Notes:

* In addition to the units of the experiment, the subject provided data on a lengthy final examination, preceded by the review of all twelve units previously learned

** This subject returned to the program late in the fourth funding period, after leaving it in 4/78.

*** The total and mean are for the nine out of ten subjects who provided ~~record~~ second period data.

were tape recordings which ranged from 50 to 60 min in length(at normal play speeds, either 1 and 7/8 ips or 15/16 ips, depending on the research phase). Before beginning any of the phases, all subjects learned from two AS tapes (i.e., two units) which concerned information on the operation of the APH tape recorders and associated equipment in the study room of the aural learning laboratory; and also, a set of general laboratory procedures to be followed.

Ten of the subjects then learned a "course" consisting of seven units of AS tapes called, Orientation to the Learning Through Listening Project. The content of these units was selected so as to be unfamiliar to all of the experimental subjects. (The titles of each of the units are reproduced in Appendix .) The materials were written at the high school level, but varied considerably, from unit to unit, in their level of difficulty.

The purpose of the pilot research phase was primarily to obtain descriptive data on study performance with AS tapes and to test out the new laboratory research tool for the analysis of tape recorder study. Thus no property of the AS tapes was varied as an independent varialbe. Our interest was to obtain information on how long it took our subjects to acquire a stable study performance with the new adaptation structure, and to identify baseline performance levels for several study activity measures, against which the performance generated in Exp. I could be contrasted.

During the pilot research phase, we developed an aural learning system (i.e., an instructional procedure) for our subjects which was then employed in Exp. I. The learning system is based in part upon the Personalized System of Instruction (Sherman, 1974; see also, Cobb, 1978). A modification of that procedure was used for Exp. III (see Section IV). In general, the following sequence of steps occured for each unit to be learned:

1) Initial study of a listening segment (LS). The subjects were always allowed as much time as they wished for study. One study requirement

which was imposed upon them was that all questions at the end of each LS on Channel A had to be responded to (by tape recording answers on a separate "response" machine, as shown in Fig. 3). If the subjects were unable to determine an answer, they simply indicated that fact in their response to the question item. (Note: All LS questions were of the short identification kind. Acceptable answers consisted of at least one sentance, and usually more than one. LS's generally contained 10 to 15 questions for the "short" AS version -- see below).

The only other restriction imposed upon aural study was no note-taking of any kind (i.e., with the response recorder or with a Braille writer). Since students vary considerably in the effectiveness with which they take notes, note-taking would have been an important confounding variable affecting study and examination performance.

2)Segment check. Having tape recorded responses to all LS questions during initial study (IS), the subject would take the response cassette to a tutor (an LTL staff member) who would listen to each answer with the subject. The tutor informed the subject as to whether each answer was correct, incorrect, or incomplete, as that fact was recorded on a segment check data sheet. The subject was then told his/her segment-check score. Subjects received no tutoring during segment checks.

Before moving on to the initial study (IS) of the next listening segment (LS) in the unit, subjects were allowed to re-study the previous LS to see if they could clear up their understanding of the LS questions they had not answered correctly.

3)Unit review. After completing the IS of the last LS in a unit, the subjects took as much time as they felt to be necessary for review study (RS) of all LS's in the unit.

4)Unit evaluation. Having completed the review (RS) of a unit, the subject obtained a unit evaluation (UE) tape which has 100 true/false and

fill/in questions about the entire unit recorded on it. As the subject listened to each UE question and tape recorded an answer to it, all operations of the playback deck were recorded in the computer just as was the case during independent study of the unit. Thus our computer-stored data include records of initial study (IS), review study (RS), and exam-taking performances. For all UE's, the subjects could take as much time as they wished.

5)Unit tutoring. Prior to advancing to the study of a new unit, subjects were tutored (one-on-one) on all unit content which was not completely understood as a result of completing steps 1 -- 4, above. Tutoring sessions lasted as long as it took to provide the subject with a thorough understanding of the content of the unit (as determined subjectively through tutor/subject questions and answers). (Note: In Exp. III, this step was omitted entirely for both experimental conditions.)

6)Mid-term and final examinations. In Exps. I and III, the subjects were required to take a mid-term examination (based upon the first six units of the Ecology course -- see below) and a final examination (based upon all 12 units of the Ecology course). These examinations were like the UE tests in terms of the types of question items (true/false and fill/in) and their administration (tape recorded and no time restriction). They consisted, however, of 300 questions rather than 100.

Experiment I. After the subjects finished the last unit of the course called Orientation to the Learning Through Listening Project, they learned one unit of a course in high school biology with AS tapes, and that ended the pilot research phase.

Twelve subjects were used for Exp. I, eight of whom had participated in the pilot research phase. The purpose of Exp. I was to examine how study performance varied as a function of LS length. While subjects were learning the "Orientation" course, we were writing two versions of AS materials to be used in Exp. I. The

twelve units of materials made up a full-length course called Ecology. As usual, all of the units were 50 to 60 min in length. Appendix A contains a Table of Contents for all of the LS's in each of the twelve units of the "short" version of Ecology.

In the "short" version, each unit contained four "short" listening segments (LS's), with a contents segment (also called LS) and a summary segment (also called LS) at the start and end of the AS tape respectively (for a total of six LS's -- see Appendix A). In the other Ecology version used in Exp. I -- the "long" version -- the length of LS's was doubled simply by combining successive LS's from the "short" version into "long" LS's. For example, for each unit of the "long" version, LS #'s 2 and 3 of the " short" version became LS #2; and LS #'s 4 and 5 became LS #3. Thus, in the "long" version, each unit contained two "long" LS's, bounded by the same contents and summary segments used for the short version (for a total of four LS's, as designated in Appendix A).

All twelve subjects learned (according to the five-step system described for the pilot research phase) the ecology course by studying from tapes in both AS versions in a counter-balanced ABAB experimental design, with alternation for each successive unit. Thus, six of the twelve subjects learned odd-numbered units with the "short" version AS tapes and even-numbered units with AS tapes for the "long" version; and the reverse was true for the other six subjects. Of the twelve subjects, nine of them finished all twelve units.

Experiment III. Since we are presenting data from Exp. III in Section IV of this report, we have elected to describe the specific procedural details of that experiment in that section. For now, we will say that, in general, we made a direct comparison of the study performance (sic) generated by two versions of the ecology course. The two versions were the "short" AS version which had been used in Exp I and an LT version of the same verbal content. Only two

subjects were used in Exp. III and, as in Exp. I, each served as his own control in an ABAB counter-balanced experimental design.

The data for Exp. III were recorded in computer memory during our fourth funding period which ran for four months, from July through October, 1978. That ended a two year period in which thousands of hours of study activity data had been recorded in computer memory from the three research phases we have described.

During the entire two year period, we had not been able to analyze the computer-stored study activity data because we were unable to develop an adequate analysis program. During that two year period, our efforts at data analysis were restricted to working from computer "dumps" of raw data. Since most individual study sessions involved hundreds of study activity events, that procedure for data analysis was, to say the least, impractical.

In November 1978, funding for the Learning Through Listening project was discontinued. However, fourteen months later, starting in February 1980, we received continuation support for a fifth funding period which extended to 28 February 1981. This final report is in reference to that fifth funding period, the purpose of which was the analysis of the computer-stored data which we had collected in the twenty-four month period from November 1976 through October 1978. Our data analysis goals and objectives for the fifth funding period will be described in the next section.

II PROBLEM STATEMENT

As indicated in the preceding section, our problem for the fifth funding period was to analyze the computer-stored study activity data which we had previously obtained during the three research phases: pilot research, Exp I and Exp III. In addition, all of those data could be analyzed at different "levels", from a gross analysis to more molecular study of the data. For example, one can describe a subject's performance with respect to the study of an entire AS tape, with respect to LS's, with respect to LS parts, and so on.

Thus, aside from Goal A, which concerned the installation of a security system in the aural learning laboratory (a goal which was accomplished at the outset of the funding period), Goals B through G all related to the accomplishment of particular kinds of data analyses. As a data analysis package, those six goals turned out to be overly ambitious. The achievement of all of them was contingent upon the achievement of a single goal --(E) -- the software development goal. Thus Goal E involved several computer program objectives which had to be completed according to a stringent time schedule if the data analysis goals were to be completed.

Unfortunately, the contract with our computer programmer which was to have been established in February, 1981 (Objective E1) was delayed because of bureaucratic red tape until June (see appropriate progress reports submitted to SED). Thus the time schedule for Goal E was completely thrown askew. For example, the revisions of existing analysis programs which were to be completed (sic) by 15 April (Objective E-3) were not even started until June, and were completed much later on in the summer. And work on Objective E-4 -- a program to obtain various statistics according to any pre-selected tape location limits, was begun late in the summer (rather than being completed by 1 June, as we had planned) and extended into the Fall months. To date, the program is incomplete,

so we have never been able to use it for accomplishing Goal F: Fine Analysis I -- an examination of samples of data from all three research phases at the LS-part level of analysis.

Work on Objective E-6, to have been completed by 15 September, was never even begun. Thus Goal G: Fine Analysis II -- an examination of samples of data appropriate to frequency distributions of study activity patterns -- a goal which required the software development of Objective E-6, was never accomplished either.

That leaves three data analysis goals (Goals B, C, and D) which were all gross-level analyses of Exp III, Exp I, and the pilot research phases respectively. Goal B (the gross analysis of Exp III) was to have been completed by 15 May. During the months of February through May, however, we were without adequate analysis programs, so hundreds of hours were spent analyzing the data of Exp III by using a hand calculator for computing statistics. By June, when the software from Objective E-3 began to become available, our work on Goal B moved along much more rapidly.

By mid-summer, we faced a turning point at which a modification of our research plan became compelling. We had almost finished the gross analysis for Goal B (Exp. III), and thus had a substantial amount of information on the study of AS tapes (we had data analyzed on the study of 12 AS tapes from two subjects). Moreover, the data from the study of those AS tapes were very stable and interpretable, especially when contrasted with the data from the study of the LT version of the course called Ecology. Therefore, to spend our remaining time in the funding period doing the same kind of analysis on the AS data from Exp I and the pilot research phase (Goals C and D, respectively), seemed to us to be of less priority than to make an attempt to address ourselves to some of the more molecular analysis questions of Goals F and G, as best as we could without the appropriate software.

Accordingly, we elected to devote the rest of the funding period to the continued examination of the data from Exp III, doing more molecular analyses by the "tally-sheet-hand-calculator" method. Although this was a time-consuming procedure, we felt that a little information about new questions would be better obtained than a lot of information about what we had already explored from Goal B. We feel now that we made the right decision, for the finer levels of analysis enabled us to interpret the data from the Goal B analysis in a much more meaningful way, as will be described in Section IV.

There are only two other goals to be discussed, Goals H and I, both of which involved dissemination of the results of the LTL project. Goal H was the most optimistic goal of all: "To write a brochure for special education teachers on the LTL project's aural learning system (ALS)." That goal was entirely inappropriate, even if all of the preceding goals had been fullfilled as planned and there had still been time left over to do it. Not that Goal H couldn't be done at this point in our research, but that it shouldn't be done, for doing it would imply that special education teachers were ready for that change -- that they had come to accept the effectiveness of AS tapes and the aural learning system, which is hardly the case. Once special education teachers become aware of research findings such as are presented in Section IV of this report (and, hopefully, additional evidence to come), an interest in the material proposed for Goal H will begin to grow. It seems that we are a long way from that point now. With no funding support for the continuation of this research presently available, the completion of Goal H would have been, to say the least, superfluous.

The other dissemination goal -- Goal I -- involved presenting the LTL results at professional conferences and in professional journals. Both of these objectives are reasonable ones, and one of them has been fullfilled once. We

presented the results of Exp III at the April, 1981 meeting of the Eastern Psychological Association in New York City. In addition, we intend to submit a series of papers to professional journals as we continue our data analysis. These papers, when published, will be distributed to appropriate individuals, especially those who have expressed an interest in our research efforts over the years.

The continuation of the analysis of the data acquired on the LTL project, and the subsequent publications which would result from those analyses, depends upon whether or not we receive additional support from other (presently federal) agencies. We now, at long last, have the capability to analyze data while we are acquiring it -- a capability we have not yet had a chance to use. Thus, if we were funded to obtain more experimental data on aural learning, we could still carry on the analysis of our previously acquired data on the LTL project. If we are not funded, the further analysis of LTL data will probably not be possible for the laboratory will be disbanded and other employment activities will preclude that job being accomplished.

III TABLES AND CHARTS

See Sections I and IV.

IV PROJECT RESULTS

As we mentioned in Section I, Exp III was a direct comparison of aural study performance as controlled by two tape recording presentation designs: the literal transcription (LT) tape and the adaptation structure (AS) tape. The former kind of tape recording is what is currently available to blind students (e.g., the tapes that are provided to blind students by Recording for the Blind, Inc.), and the latter is a presentation structure which we have developed on the LTL project. Thus the experimental question being asked here was, "Does the study performance generated by LT tapes differ from that generated by AS tapes, and if so, in what ways?"

Since each of the two subjects served as his own control, we will present the data for one of them and comment, when appropriate, about the performance of the other, especially in those cases where it contrasts with the first subject. In this manner, a complete picture will be provided for a single performance. Also, as we describe the data we present, we will discuss them and offer interpretive remarks. At the end of Section IV, we will summarize our findings and the conclusions we have drawn from them.

Method for Experiment III

Subjects. Two adult (24 and 27 years old), visually impaired males served as subjects in Exp. III. Both were high school drop-outs. With few exceptions, they came to the aural learning laboratory two days per week over a period of four months. On each day of attendance -- what we call a study day -- they generally studied (or took an examination) for two sessions, morning and afternoon. Such sessions ranged from one to three hours depending upon a variety of factors.

During their participation as subjects, neither man was enrolled in any school, although both were enrolled in non-academic programs at the New York Association forthe Blind ("Lighthouse"). Both subjects were naive. That is, they had never been associated with the LT project and thus had never before studied from AS tapes. Both, however, had studied academic material from LT tapes in the past. They received the minimum wage for serving as subjects.

Learning materials. Prior to learning the twelve-unit ecology course, both subjects learned from three AS tapes which provided practice in using the new adaptation structure. The first two tapes were about the use of laboratory equipment and laboratory procedures (see p. 24). And the third AS tape was the last unit used in the pilot research phase -- the high school biology tape (see p. 26). This AS tape was exactly the same format as the "short" AS version of the ecology course (see p. 27, Appendix A, and Fig. 6).

Two versions of the ecology course were used as learning materials in the experiment proper (i.e., after the AS practice tapes had been learned). Figure 6 is a diagram illustrating both tape recording versions (AS on the top and LT on the bottom) for a single unit of the ecology course (Unit #12). Note that it is the "short" AS version which is the one used for Exp. III. Listening segments (LS's) 2 through 5 are standard (i.e., each consists of the four LS parts recorded on two concurrent tape tracks, Channels A and B), and are bounded at the tape terminal points by a contents segment (LS #1) and a summary segment (LS #6). Continuous index tones (solid vertical bands) separate all LS's, while pulsating index tones (broken vertical bands) separate LS parts. For a description of the aural adaptation structure, see Fig. 1 and pages 8 -- 12 (Section I).

All twelve units of the literal transcription (LT) version of the ecology

Figure Legend

Figure 6. Two versions of a tape recording used in Exp. III. The upper diagram shows the "short" version of the adaptation structure (AS) of unit #12 of the ecology course. The unit contains four listening segments (LS's 2 -- 5), with four parts to each LS, two on Channel A and two on Channel B. The vertical bands are index tones separating LS's and LS parts. The unit begins with a contents (CTS) segment and ends with a summary (SUM) segment. In the lower portion of the diagram, the literal transcription (LT) presentation format is shown. The single-track LT version was constructed from the AS version. That is, the two versions are verbally identical.

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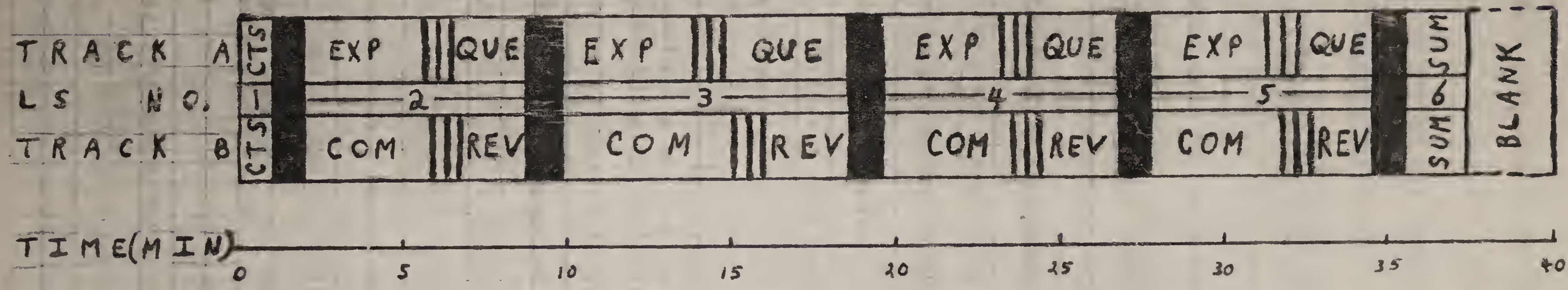
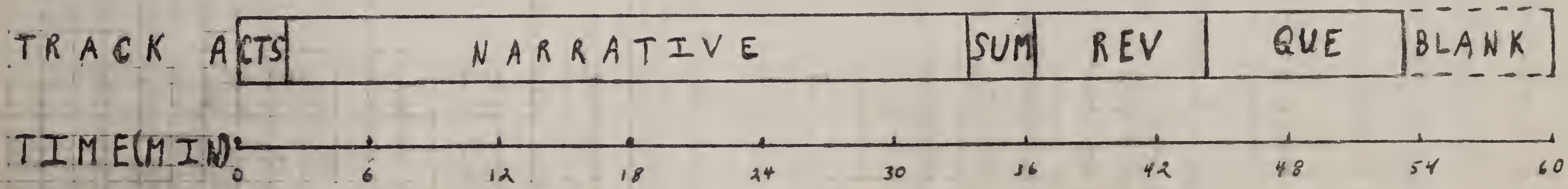
UNIT PRESENTATION FORMATS

ADAPTATION STRUCTURE(AS) TAPE



NORMAL PLAY SPEED

LITERAL TRANSCRIPTION(LT) TAPE



NORMAL PLAY SPEED

FIGURE # 6

course (see the bottom of the diagram in Fig. 6) were constructed from a written copy of the "short" AS version. That is, the content of each tape recording version (AS and LT) of all twelve units of the course was, word for word, identical. Or, the only difference between the AS and LT versions of the ecology course was the tape location distribution of the content.

Thus the LT contents section (CTS, in Fig 6) was arrived at simply by recording the AS contents segment on a single track (the AS Channel A material followed by Channel B). Similarly, the narritive section of the LT version consisted of the exposition-commentary sequences of LS #'s 2 -- 5, recorded consecutively as a continuous, single-track section of prose -- a section of slightly over one half-hour at normal play speed(in the example shown in Fig. 6). The other three LT sections (summary, review and questions) were also composed from the AS version in the same manner.

It is important to note that what makes an AS tape different from an LT tape -- at least in this experiment -- is not the verbal content for, again, the two versions are identical. But rather, it is the distribution of the content. In the AS version, small amounts of nattative (3 to 5 min of recording at normal play speed) were associated in close proximity with question and review items which refer to thosenarrative portions. In the LT version, all of the question and review items are, relatively speaking, quite remote from the narrative to which they refer.

It is also worth noting that the LT version used here has certain advantages (inherited from the content of the AS version) which are not at all typical of LT tapes of most textbook chapters. For example, because questions and review items are an important property of our adaptation structure, there are many more of them (relative to the narrative length) than is usually the case in a textbook. Thus, in Fig. 6, the non-narrative sections of the LT unit consitute about 40% of the verbal content of the entire unit. In contrast, in most textbooks,

we estimate that the non-narrative sections make up no more than 5 to 10% of chapters. Indeed, in some textbook chapters, some, or even all, non-narrative sections are omitted completely.

This substantial deviation of our (i.e., in Exp III) LT version from the typical textbook LT version is important because it is _a deviation in the direction of_ the adaptation structure. It actually _reduces_ the difference in our two experimental conditions over what would otherwise (in "real life") be the case. That is, we can say at this point that any differences in study performance generated by the two versions shown in Fig. 6 will be differences produced _in spite of_ the fact that our LT version contained several AS properties designed to enhance aural learning.-- properties which are not ordinarily available to blind students studying from LT tapes.

Procedure. All three practice units -- the two AS tapes on laboratory equipment and procedures, and the AS tape on high school biology -- were learned according to the five-step _aural learning system_ described on pages 24 -- 26. That is, the subjects were allowed as much time as they wished for _initial study_ (IS) of a listening segment (LS) -- step #1; after tape recording all answers to LS questions, the subjects took a _segment check_ -- step #2; once the last LS in a unit had been completed, the subjects could engage in as much _review study_ (RS) as they wished -- step #3; a _unit evaluation_ (UE) of 100 questions was then taken -- step #4; and following that test, the student received _unit tutoring_ to make sure that he understood all the material -- step #5.

In learning the 12 units of the ecology course, the same procedure was followed, except that step 5 -- the unit tutoring -- was omitted. No instruction of any kind was given throughout the entire experiment. During segment checks, however, the subjects were told which answers to LS questions were correct, incorrect, and incomplete, but never _why_ they were designated as such. And, after

each unit evaluation (UE), the subjects were merely informed of their true/false score, their fill/in score, and the total score.

As mentioned before, the subjects were not allowed to take any notes at any time while they were in the aural study room. Thus differences in study performance were not confounded by either of two very important variables: instruction or note-taking ability.

As in Exp. I, the subjects in Exp. III each served as their own controls in a counter-balanced ABAB experimental design. That is, the twelve-unit ecology course was divided into four blocks of three units each. Tape version (LT or AS) was alternated on each block, and each subject began Block #1 with a different tape version. Thus each subject studied six units of the ecology course with each tape version, and the AS units for one subject were the LT units for the other subject.

At the completion of the sixth unit, a midterm examination was administered to both subjects; and after all twelve units had been completed, each subject received a final examination covering the content of all twelve units. The question items in both exams represented the units covered uniformly. Thus, for example, the 300-item final examination contained exactly 25 questions drawn from each of the twelve units.

Results and Discussion of Study Performance Data

In opting for a relatively thorough study of the data from one experiment, rather than spending our time in the gross analysis of Exp I and the pilot research phase, we examined the data of Exp III from a number of different angles. For example, we plotted over 100 graphs for the study performances of our two subjects, and we checked out several other relationships by examining tabular data.

Thus our presentation here will represent only a small fraction of the

analysis available to date. We have selected a few graphic presentations which we feel are most illustrative of the major generalizations we will be making. Subordinate facts will generally be conveyed as verbal statements. Still, for one reason or another, there will be many kinds of subordinate relationships which we will not comment upon at all.

Data on study durations. As we have mentioned, both subjects completed all 12 units of the experimental learning materials in about four months. Subject #25 completed Unit #1 in three study days, and each of the other 11 units in two study days. (A study day generally involved both morning and afternoon study sessions which lasted anywhere from one to three hours.) The other subject, number 26, was a slower learner, but was almost as consistent, completing nine of the units in three study days (plus or minus one, for the other three units).

We have defined total days/unit as the number of days elapsing from the start of one unit to the start of another. With respect to that datum, both subjects averaged about one week per unit, but there was much greater variability, the range being from two to fifteen days. Still, in relation to the way most students study homework when they are in school, this performance was probably the more regular of the two.cases.

However, with neither measure (study days nor total days) was there any difference between block conditions (i.e., tape version) for either of the subjects. Nor was there any "practice-effect" trend for these two measures accross the four months of learning the twelve ecology units. Or, as measured by number of days to study units, AS tapes do not differ from LT tapes.

A finer measure of study duration is total study time (TST). For the study of any unit, or part thereof, TST is simply the total number of minutes the subject spent at the study station in the aural learning laboratory or, more technically, the cumulative number of minutes of computer time.

The solid curves of Fig. 7 show TST (left ordinate) as a function of

Figure Legend

Figure 7. Total study time (solid curves, left ordinate) and study type percent (broken curves, right ordinate) for each of the 12 ecology units. Open and solid points differentiate IS and RS respectively. Blocks 1 and 3 show data for the study of LT tapes. Blocks 2 and 4 are for the study of AS tapes. All unconnected points show means for the four blocks. Data are from Subject #25.

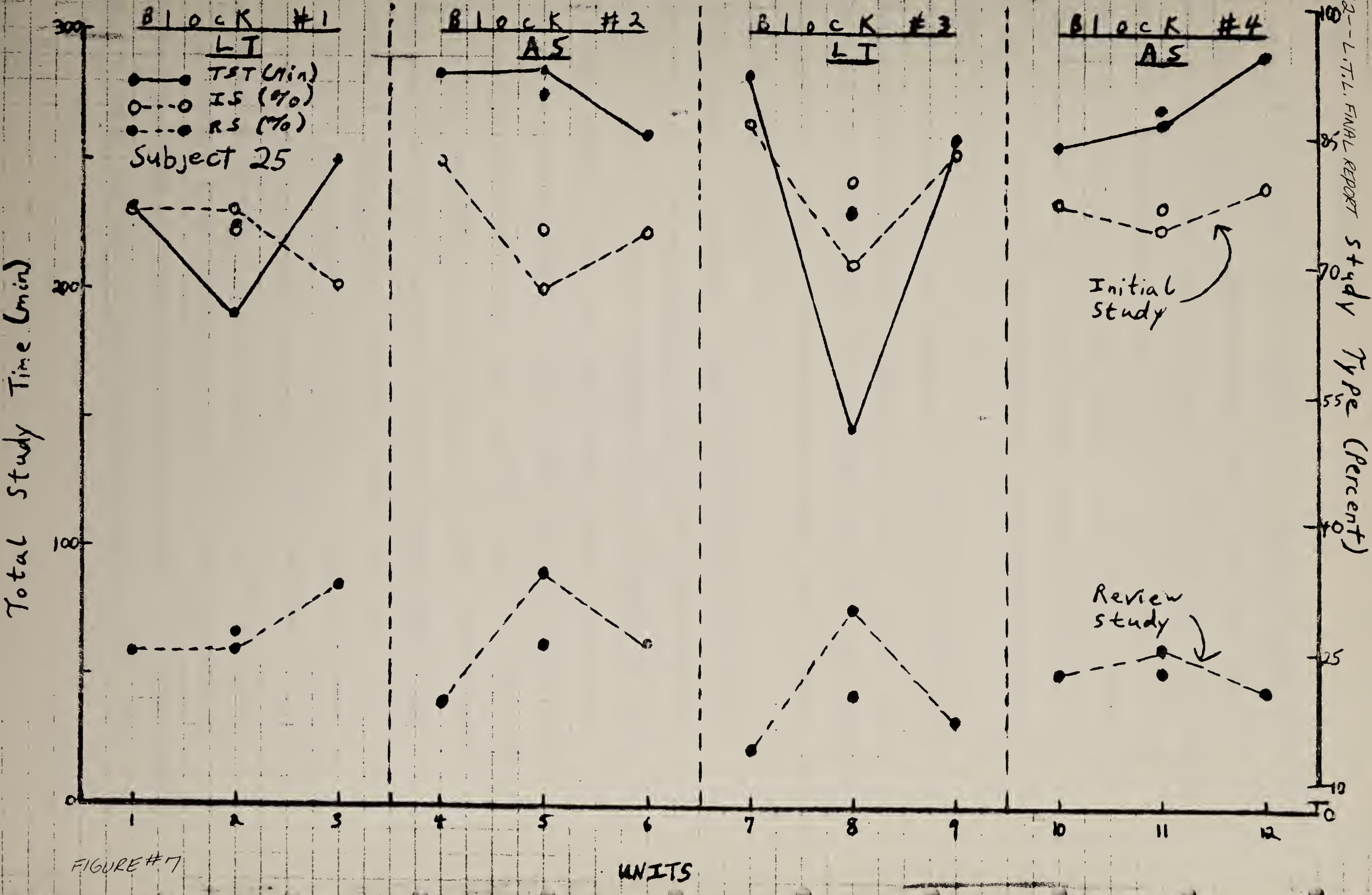

BLOCK #1
LT
BLOCK #2
AS
BLOCK #3
LT
BLOCK #4
AS
TST (Min)
IS (%)
RS (%)
Subject 25
Initial Study
Review study
Total Study Time (min)
Study Type (Percent)
300
200
100
0
100
85
70
55
40
25
10
0
1
2
3
4
5
6
7
8
9
10
11
12
UNITS

FIGURE #7

ecology units for Subject #25. All unconnected points show block means. The basic design of Exp III is apparent from an inspection of this figure. The ecology course is divided into four blocks of three units each. The subjects were exposed to a different tape structure (LT or AS) in each successive block, and each subject began Block #1 with a different structure (LT for Subject #25 and AS for Subject #26), so that study performance differences controlled by content difficulty can be distinguished from those controlled by changing the tape presentation structure.

Figure 7 shows that there is no substantial or systematic difference in the amount of time Subject #25 spent studying the two kinds of tapes. The TST ranges from about three to five hours (at normal play speed, total recording time ranged from 50 to 60 min), and the variance is larger for LT (Blocks 1 and 3) than for AS tapes (Blocks 2 and 4).

Content difficulty is probably an important determinant of TST (rather than tape structure), and one indication of that is the close correlation between the two subjects. The data for Subject #26 were different in that he took more time to study all the units (five to eight hours), but relatively speaking, his data followed closely the TST per unit for that of Subject #25 (i.e., the mean TST for Blocks 2 and 4 were also higher than for Blocks 1 and 3 for Subject #26). The correlation between subjects also held within blocks.

Total study time (TST) is composed of time spent during initial study (IS) sessions and review study (RS) sessions. Initial study (IS) is defined as all study up to and including the tape recording of answers to questions on the study tapes. Review study (RS) includes all study time spent in preparation for any examination, whether it be a unit evaluation, a mid-term, or a final examination. However, RS data for the three tests are treated separately.

Figure 7 also shows the percent (right ordinate) of TST for those two types of study. It may be seen from the broken curves that Subject #25 was very con-

sistent in how he distributed his time for each unit (quite independently of tape structure). Generally, about 75% of TST is spent as IS (open points) and 25% for RS (solid points). The relative amount of time spent on IS and RS was also remarkably constant for Subject #26, although he spent a greater proportion of study time on IS (81% to 88%).

Thus, from the study time data considered so far, we can say that it does not appear that AS tapes per se take longer or less time to study than LT tapes. The amount of time spent studying tapes is probably controlled mostly by content difficulty and, as we shall see below, the interaction between tape structure and study strategy. In addition, it appears that tape structure has little effect upon the proportion of time spent in each type of study (IS or RS).

In addition to dividing up total study time (TST) into the components of initial study (IS) and review study (RS), TST can also be partialed out into two other components: "active" study time (AST) and study "break" time (SBT). "Break" time is measured as cumulated stop times of > 30 sec. "Active" time is all the rest of the study time (i.e., TST = AST + SBT).

Does this mean that if the subject stops the tape recording for more than 30 seconds he is necessarily on a study "break" (e.g., not thinking about the study material)? Certainly that is not necessarily so, although, under the conditions of Exp III, in most cases we feel that it is probably so (see below). Nor does our distinction between AST and SBT mean that during "active" study time (e.g., time spent in the play mode, or stop times < 30 sec) the subject is necessarily engaged in thinking activities concerned with the study material; but again, we feel that in most cases that is probably so also, at least when the subject is using an active study strategy (see below). Describing the distinction in terms of "active" and "break" may be a mistake, for those terms imply much more than we wish to say at this point in our ignorance, but we are sticking with them for this report.

Actually, it is not necessary to infer differential thought properties from the behavioral properties which differentiate performance during active study time from that during study break time. And another point, as far as effective study is concerned, even if subjects were "day dreaming" during study break time, such episodes may well be as important to productive independent study as any other kind of covert process which goes on. Thus the question arises, why make the distinction between AST and SBT at all?

One answer lies in the fact that the dichotomy is inherent to the data on stop durations during study. That is, the frequency distributions of stop durations are often bi-modal, with 30 sec (or thereabouts) being a cut-off point. And when those distributions are uni-modal, the upper end of the distribution fluctuates around 30 sec (for the subject matter of Exp. III. One would, of course, expect the duration of the cut-off point to be a function of the type of subject matter being studied. It would, for example, be expected to be much higher than 30 sec for the study of mathematics.)

Another answer to the question of why make the AST/SBT distinction concerns a reasonable assumption about the stimulus control of covert (i.e., thinking) study activities. When a subject is in the play (P), rewind (R), or fast forward (F) modes, it is reasonable to assume that the study material he is hearing (or has just heard) is exerting a control over his covert study activities. Not always is this so, but it is more likely than during "break" time. That same assumption is still reasonable for stop durations of $\leq$ 30 sec. However, considering the fact that no note-taking of any kind was allowed in Exp III, that assumption becomes less and less reasonable to make as stop durations increase past 30 seconds.

This interpretation is in accord with the introspective reports of both subjects obtained at the end of the experiment. When asked if they were "thinking about" the study material when they stopped the tape recorer for more than half a minute, they both replied that they were usually not thinking about it. "Just

taking a break", as one put it, from whence we obtained the designation, study "break" time (SBT).

Having made the distinction between AST and SBT, there are some facts to report about those variables. For example, for both subjects, study break time (SBT) did not change appreciably across all four blocks. That is, there were no significant differences in the absolute amount of SBT (or, for that matter, in the proportion of SBT) for the different tape structures. For Subject #25, the average SBT ranged from 19% to 23% of the TST; and for Subject #26, SBT ranged from about 10% to 18% of the TST.

These data suggest that the activities which occur during SBT may be important to effective independent study. That is, study break time is a stable phenomenon which occurred for two subjects over a four month period of studying twelve units of course material. Also, the relative amount of SBT did not change when the tape structure was changed. But does study break time remain constant under all study conditions of Exp. III? Figure 8 shows that it does not; that most break time for Subject #25 occurs during initial study (IS), with very little occuring during review study (RS) sessions.

The ordinate of Fig. 8 shows break time relative to active time. The open points show the SBT/AST ratio for IS sessions, and the solid points are for RS sessions. As already mentioned, it may be seen from Fig. 8 that the probability of engaging in a study "break" (i.e., stopping the tape recorder for more than 30 sec) is not related in any systematic way to tape structure, but instead is significantly related to the temporal proximity of a unit examination. That is, breaks during review study (RS) seldom occur, and RS sessions occur when the subject is preparing for an examination(here, a UE). During the initial study of tapes, however, long breaks are a relatively frequent occurrence. This highly significant difference between relative "break" time for IS and RS sessions was also true for Subject #26, for 8 out of the 12 ecology units.

Figure Legend

Figure 8. Relative study break time (SBT/AST) for IS (open circles) and RS (solid points) sessions. Blocks 1 and 3 show units in which LT tapes were studied. Blocks 2 and 4 are for the study of AS tapes. Unconnected points show block means. Data are from Subject #25.

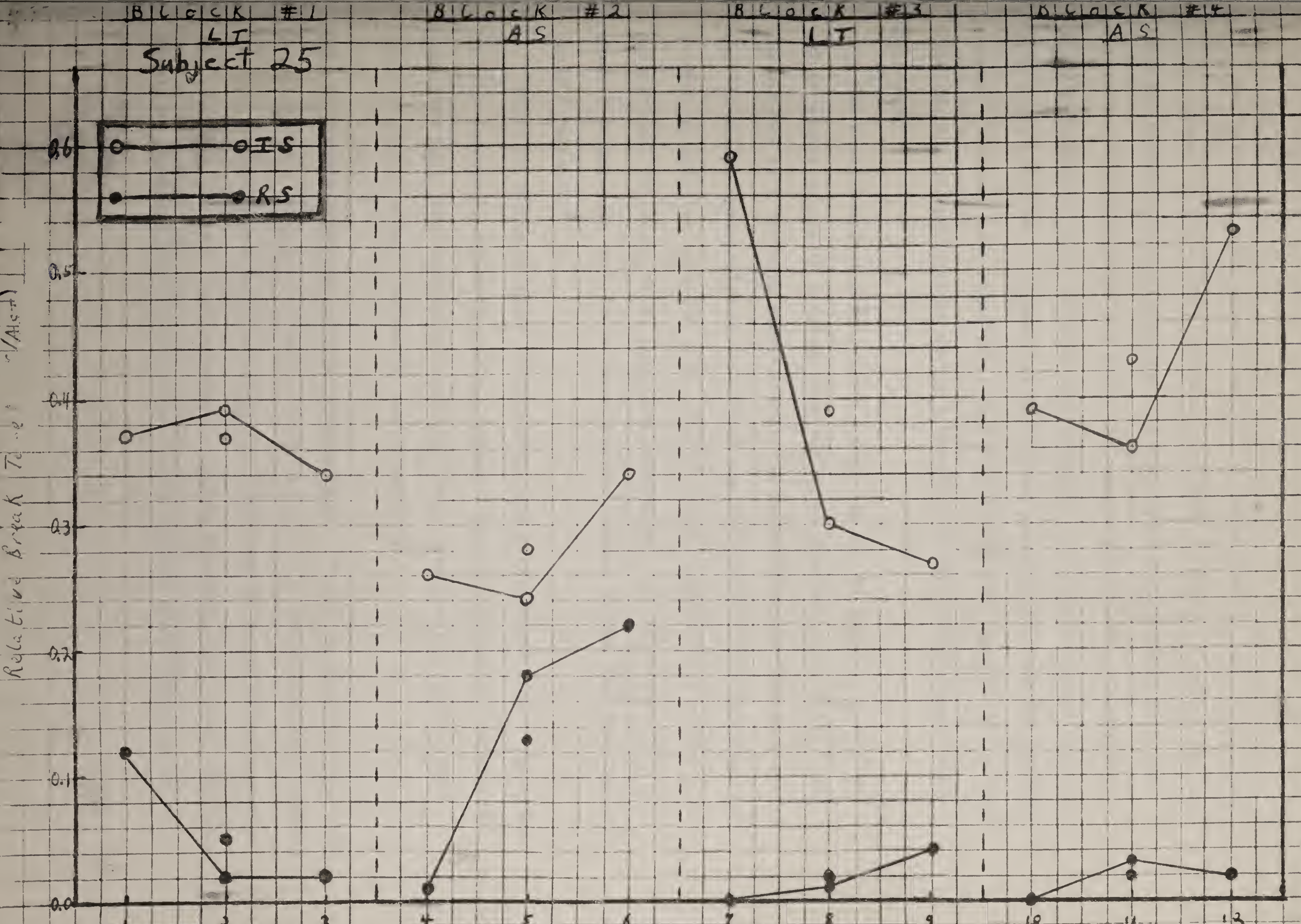

Block #1
LI
Block #2
AS
Block #3
LT
Block #4
AS
Subject 25
IS
RS
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Relative Break Time (1/Ais+1)
1
2
3
4
5
6
7
8
9
10
11
12
Units

FIGURE #8

The fact that study break time (SBT) is sensitive to the type of study being engaged in (IS vs RS) is another arguement in favor of making the distinction between the two variables. It has always been obvious that the occurrence of examinations and tests can have an effect upon independent study performance (e.g., witness the occupancy of a school library shortly before and after the occurrence of a mid-term examination), and the relative amount of SBT may have significant implications for the analysis of how the distribution of examinations within a semester or term can influence study behavior.

The close temporal proximity of a test may not be the only reason why SBT is higher during IS sessions than during RS sessions. In review study, the subject is a lot more familiar with the material than is the case during initial study. Thus relative break time may be related to how familiar the student is with the material being studied, quite independently of the motivational influence of an impending examination. It is matters such as these that are wide open for an experimental program of SOS (for the "study-of study") research.

There is one other point to make about the active/break time distinction. In many instances, statistics (e.g., response rates) based upon active study time show much less variability than when based upon total response time. That is another reason for making the distinction.

Data on overall levels of activity during study. So far as we have seen, study duration, as a dependent variable, is not sensitive to the independent variable of tape recording presentation structure. That lack of relationship is not at all the case, however, when we consider various mearuses which index different levels of study activities which occur in the various study durations we have discussed.

Thus, in Fig. 9, may be seen the first study performance differences which can be unequivocally attributed to altering the tape presentation structure as an independent variable in Exp III. Two gross, overall measures of study activity level are shown for Subject #25. The solid curves (read from the left ordinate) show the total number of responses per unit. As used here, the term "response" refers to any operation of the play-back deck which the subject performs and which is recorded in computer memory. Thus total responses is the measure of all tape recorder operations in all four of the tape recorder modes, collectively. The other measure shown in Fig. 9 is active response rate (broken curves, right ordinate). This datum is computed as the total number of responses per minute of active study time.

It is clear that both measures of activity level are very well correlated, but the active rate measure has less variance than the total number of responses. There are two highly significant kinds of differences to be noted in Fig. 9. The most obvious is that AS tapes control a much higher level of overall activity than do the LT tapes. The mean number of responses for Block #2 is larger than that for Block #1 by a factor of more than 2.5. That difference has increased to a factor of more than 3.0 for the last six units of the ecology course (Blocks 3 and 4). And, as may be seen, similar differences of the same order of magnitude hold for the active rate measure of study activity.

The other kind of change seen in Fig. 9 is that the overall level of study activity is decreasing significantly as a function of the number of units studied. For example, responding in Block #3 is about one-half that for Block #1, and significant differences are seen between Blocks 2 and 4, although the relative decrement for AS tapes is not as large.

We will be referring to these two kinds of differences -- those between levels of study activity for the different tape presentation structures (i.e., differences between successive blocks, in the design of Exp. III), and differences

Figure Legend

Figure 9. Total number of tape recorder responses (solid curve) and active response rate (broken curve) for the two block conditions of tape presentation structure. Blocks 1 and 3 show data for the study of LT tapes. Blocks 2 and 4 are for the study of AS tapes. Unconnected points show block means. Data are from Subject #25.

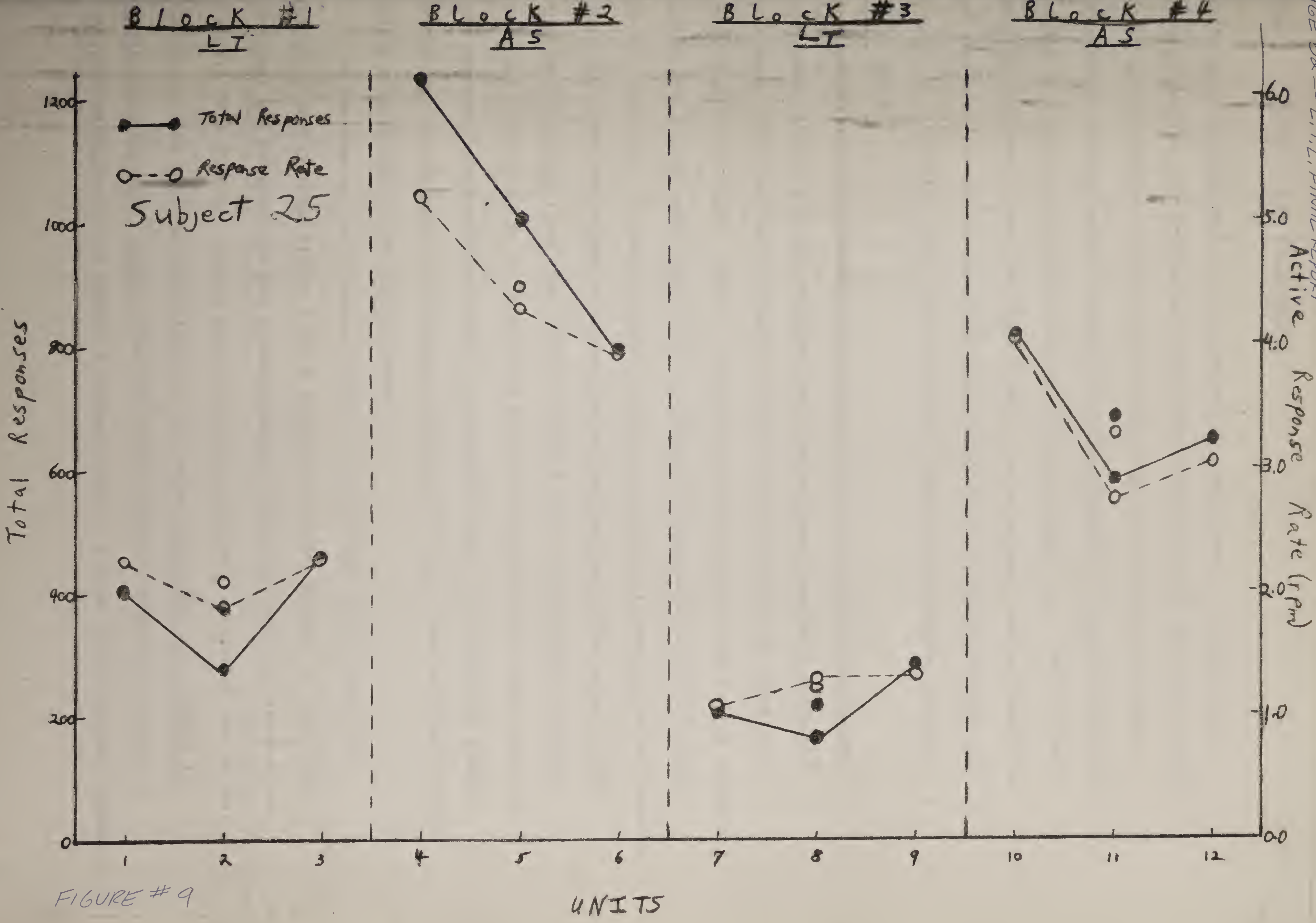

BLOCK #1
LT
BLOCK #2
AS
BLOCK #3
LT
BLOCK #4
AS
Total Responses
Response Rate
Subject 25
Total Responses
Active Response Rate (rpm)
0
200
400
600
800
1000
1200
0.0
1.0
2.0
3.0
4.0
5.0
6.0
1
2
3
4
5
6
7
8
9
10
11
12
UNITS

FIGURE #9

which occur withing each of the experimental conditions -- throughout the Results section. At this point, the reader should note the fact that, alone, these gross measures of study activity show that the two tape structures necessarily produce vastly different study performances, that the subject is a good deal more active when studying with an AS tape (i.e., the play-back deck is operated a great deal more often). As we present data at finer levels of analysis, it will be seen that these differences in overall activity are the result of differences which occur for every kind of tape recorder operation: P, R, F, and S.

As far as the decreases across both odd- and even-numbered blocks are concerned, there is strong evidence that they represent entirely different processes. The decrease in overall study activity level for AS tapes is a real "practice effect". That is, analysis of data from individual study sessions across the six AS units shows that the amount of interaction with the content (e.g., the number of searches made for the purpose of re-listening) is not decreasing, but rather the number of operations per interaction is the major reason for the decreasing trend seen between Blocks 2 and 4. The subject is simply becoming more effecient at interacting with the adaptation structure, and thus the decrease in the activity level is a learning curve. (It should be remembered that the subjects had learning experience with only three AS practice tapes prior to starting on the ecology course.)

In the case of the LT tapes, however, the decrement in the level of activity seen between Blocks 1 and 3 is *not* a "practice effect" at all (remember that the subjects had had pre-experimental experience with the study of LT tapes). Thus what is changing here is not the efficiency with which the subject interacts with tape recorded material, but rather *the number of attempts at interacting with the content*. Thus the study activity change is not a reflection of learning, but rather a decrement due to a kind of motivational change.

What we mean when we speak of an interaction during study will become clearer from an examination of records of responding during individual study sessions (see below). For now, an interaction during study involves relating one part of the tape to another -- i.e., listening to one part of the tape, and then a different part, by using the F or R buttons between successive play responses.

This dual interpretation of the study activity decrements for the two types of tape structure (i.e., a change in study efficiency vs a change in the amount of study interaction) will be supported by data to be presented below. We should point out here, however, that the data on overall study activity level for Subject #26 confirm the above analysis, but will not be presented at here for they differ in certain ways which will be quite interpretable in terms which we will first apply to the data of Subject #25.

In Fig. 10, the active response rate shown in Fig. 9 has been partitioned into the two study-type components -- initial study (IS) and review study (RS). For both experimental conditions, IS rates (solid curves) are always significantly higher than RS rates (broken curves); and again, the explanation for this difference is not the same for the two tape structures. Clearly, if content is fairly well-understood during IS sessions, the amount of interation needed for review study will be less than for IS, for there would be less material the subject would want to interact with, provided the subject is reviewing selectively. That is, if the subject has, for example, understood half of the concepts during IS sessions, then during RS sessions, if he is reviewing selectively, he would presumably interact with only that material which remained unclear to him. And that is the main reason for the difference between IS and RS rates during the study of AS tapes (Blocks 2 and 4 in Fig. 10).

That is, however, not the reason for the IS/RS rate differences seen for the study of LT tapes (Blocks 1 and 3 in Fig. 10). For the most part, the

Figure Legend

Figure 10. Active response rate for initial study (solid curve) and for review study (broken curve) for each of the ecology units in Exp III. Blocks 1 and 3 show data for the study of LT tapes and Blocks 2 and 4 are for AS tapes. Unconnected points show block means. Data are from Subject #25.

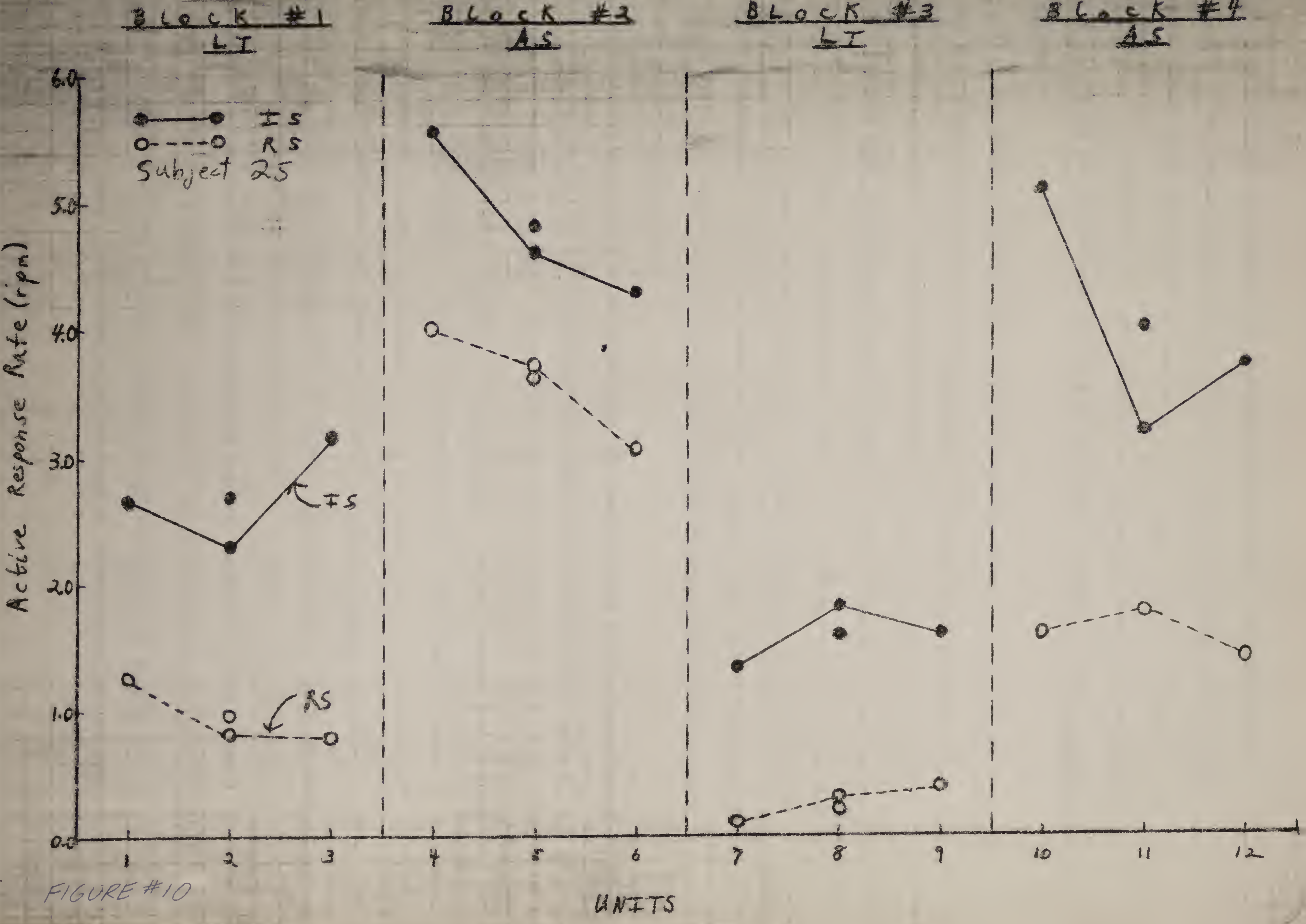

BLOCK #1
LI
BLOCK #2
AS
BLOCK #3
LI
BLOCK #4
AS
IS
RS
Subject 25
Active Response Rate (rpm)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
IS
RS
1
2
3
4
5
6
7
8
9
10
11
12
UNITS

FIGURE #10

subject does *not* study selectively during review sessions. In contrast to the study of AS tapes, there is very little RS interaction with the LT tapes, and it may be seen that activity reaches a very minimal level by Block #3. In that block, for the most part, the subject is "reviewing" for unit evaluations by re-listening to the LT tape in its entirety(which is what we call *non-selective review*).

Thus the IS/RS differences in response rate seen for the study of AS tapes are largely the result of more *selective* interaction during RS than during IS sessions; but the IS/RS differences seen for the study of LT tapes merely reflect *less interaction* during review for unit evaluations than during initial study sessions. Considering the fact that the amount of IS interaction is very low for LT tapes in the first place, these differences between AS and LT study performance are all the more striking. Again, the data for Subject #26, although different (and thus will be considered later), add considerable support for the above interpretation.

Before looking at levels of study activity for the four tape recorder modes separately, we would like to re-introduce a concept that we mentioned before, the concept of *study strategy*. In particular, here, we will talk about two kinds of strategy extremes: *passive* and *interactive*. In the former, the subject makes little or no *attempt* to search for material which, for example, would help to clarify matters if it were re-listened to. On the other hand, an interactive study strategy involves a high frequency of re-listening *attempts* (whether successful or not). For example, with AS tapes, a going-back-and-forth between the itemized LS parts and the narrative LS parts is a typical form of interaction which seldom occurs with the comparable content sections of the LT presentation structure for Subject #25. However, it occurs quite often for Subject #26.

Thus the interactive strategy involves a high frequency of *trying* to interact. With AS tapes, that results in one kind of interactive performance;

with LT tapes, quite another. For example, with AS tapes, it results in a high frequency of *selective re-listening*; and (as will be shown below) with LT tapes, it results in a very high percentage of study time spent in *searching* activities (and relatively little selective re-listening). In contrast, the passive strategy involves few attempts at re-listening at all. And when re-listening does occur, it is generally *non-selective*. That is, passages of content are generally re-listened to in their entirety, and the selection of passages is most often governed by their spatial proximity to current tape location, or by some other highly discriminable tape location (e.g. the beginning of the tape).

Thus, as we now go on to examine study activity at finer levels of analysis, the reader may keep the following generalization in mind. The tape structure used in Exp. III has two kinds of main influences over study behavior:

1)The tape structure (AS or LT) exerts a strong influence over which study strategy -- interactive or passive -- is employed.

2)When the subject is using an interactive study strategy, the tape structure produces entirely different interactive performances which, for now, we will lable as *effecient* (AS) and ineffecient (LT).

Data on the amount of responding in the separate tape recorder modes. The use of the fast forward (F) mode is a sensitive indicator of the amount of interaction a subject has with either tape presentation structure, even moreso than the use of the rewind (R) mode. That is because F responses are usually necessary for *searching* for a particular target passage and for *selective re-listening*, two aural study activities associated with an interactive strategy. So are the R responses, but they can and do occur for other, non-interactive study activities.

Thus, when R responses are not accompanied by F responses, one cannot infer much selective study. For example, if the subject often rewinds to a particular, highly discriminable tape location, and then relistens to all or most of the

rewound tape portion, the amount of re-winding (as measured by centimetres of tape, for example, or time in the rewind mode) can be fairly substantial, and yet the subject is not studying very interactively in the sense that he is not being selective in his relistening. He is not selecting, but rather a discriminable tape location is determining the start of target material; and, in relistening to all of the rewound tape, he is not selecting any verbal particular either.

In the above example, which is quite typical of a relatively passive strategy employed with LT tapes, both the absolute number and rate of R responses will be low (e.g., in an extreme case, one R response in nearly two hours), but the proportion of R responding can turn out to be relatively high. For example, in a two-hour study session with two P response and one R response, the percent of R responding is a high 33%. But there is also a study pattern where both the number and rate of R responses can be quite high, and still the re-listening is more characteristic of a passive rather than an interactive study strategy. This is the case when the subject quite often rewinds a short distance to relisten to what he has just heard. But here again, the study strategy is not content selective. Instead, the start of target material for relistening is governed by time (e.g., three or four seconds of an R response) rather than content, followed again by relistening to all of the rewound tapes.

Therefore, R responding alone, whether it be measured by number of responses, response rate, proportion of responses, modal duration, or amount of tape, does not necessarily provide the basis for inferring an interactive study strategy. But when it is accompanied by a high frequency of responding in the F mode, that combination is a strong indication that the subject is using a content selective, interactive study strategy. That is because the F mode is most often used when the subject is returning to resume listening to a passage after having relistened to prior content related to it.

For example, the subject may hear a review item or a question item which he does not fully understand. The explanation is somewhere in the narrative. A search is made, and the target passage in the narrative is located, *after* which the F button is used to *return* to the tape location from which the search originated. In the process, the F button is usually also used during the search for the target passage, and the return search for the starting-out location. This is especially true of the interactive strategy with LT tapes, where searching takes much time and lots of F, R and P responses of very short duration.

As another example (usually only with AS tapes), the subject will often interact selectively between the two narrative portions of the listening segment, since the commentary of a given LS is always *about* the exposition, and often helps to explain it. Here again, the F mode is often used, although not as extensively as in the case where interaction occurs between the itemized and narrative portions of the tape.

Figure 11 shows the number (left ordinate, solid curves) and percent (right ordinate, broken curves) of F responses for Subject #25. Here it may be seen that both absolute and relative measures are much more frequent during the study of AS tapes than is the case for LT tapes. Again, these highly significant differences are a manifistation of the fact that, for Subject #25, the two tape structures control, for the most part, different study strategies (passive/non-selective for LT tapes and interactive/content-selective for AS). The passive strategy is especially notable by Block #3, where the F mode is seldom used at all. The small amount of F responding which is seen in Fig. 11 occurs entirely for initial study (IS) sessions.

As we have mentioned in connection with the overall measures of study activity level, the decreases in F responding between Blocks 1 and 3 are almost entirely due to a change to a more passive study strategy. The subject, as it were, has just about "given up trying" to interact with the LT structure by

Figure Legend

Figure 11. Number (left ordinate -- solid curve) and percent (right ordinate -- broken curve) of forward (F) responses as a function of units. Blocks 1 and 3 show data for the study of LT tapes. Blocks 2 and 4 are for AS tapes. Unconnected points show block means. Data are from Subject #25.

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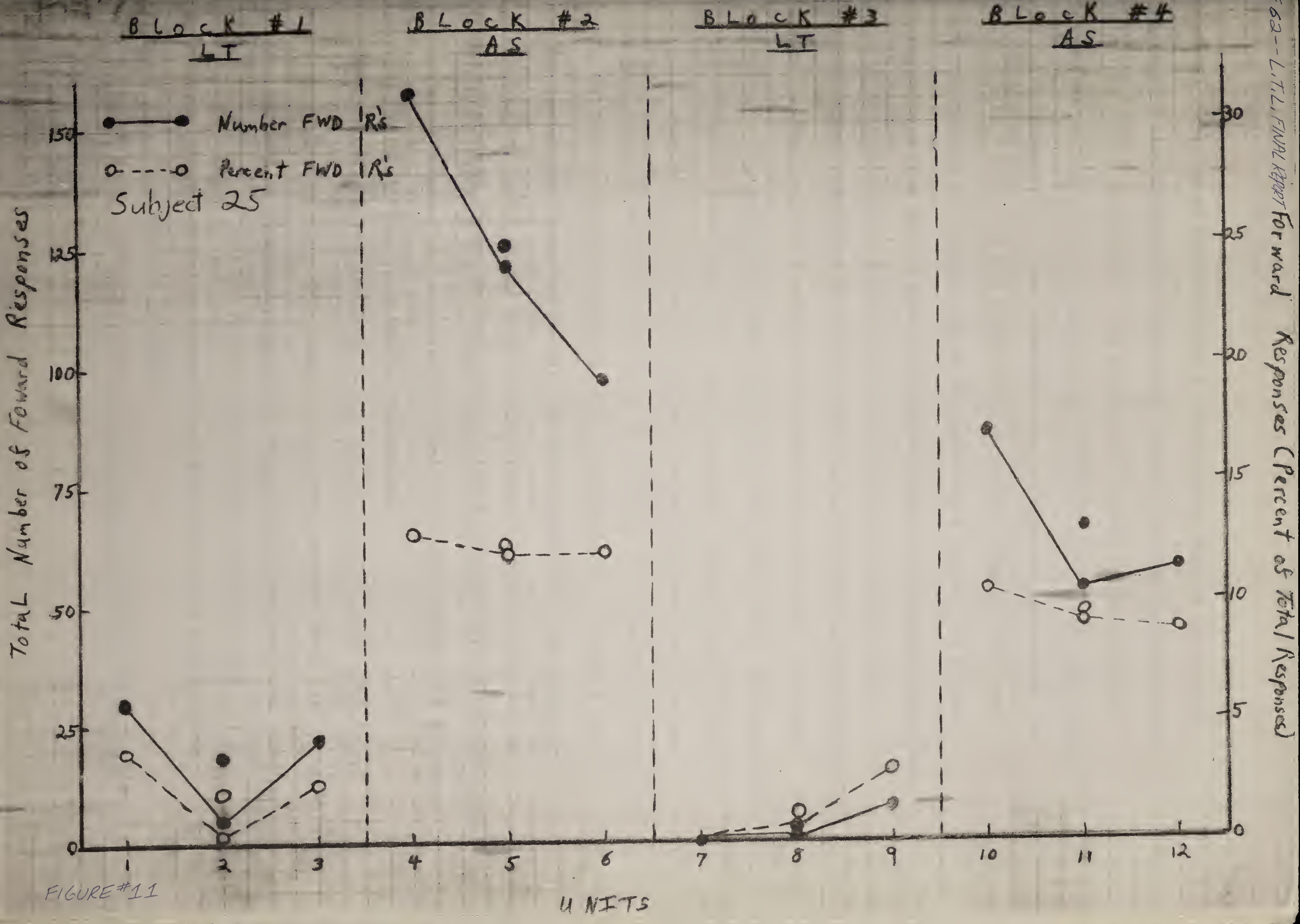


FIGURE #11

Block #3. And, as we also described for the data of Figs. 9 and 10, the decreased F responding for AS tapes seen in Fig. 11 is the result of more effecient content interaction. In general, the number of tape recorder operations per search is decreasing across Blocks 2 and 4. For that reason, the total numbers of F, P and R responses per unit are all decreasing for those blocks. And since the number of stop responses remains about the same, the percent of the other three responses drops a bit. For example, it may be seen from Fig. 11 that the relative number of F responses decreases continuously across AS units from about 13% (in Unit #4) to about 8.8% (in Unit #12).

As we have mentioned, for Subject #25, the percent of F responding during RS sessions dropped to zero for the entire third (LT) block. That is, for Units 7 -- 9, Subject #25 made very little use of the F mode, and then only during IS sessions(see Fig. 11). Just the opposite happened for the study of AS tapes, however, That is, proportionately, Subject #25 used the F button much *more* during RS sessions than during IS sessions. For example, in Block #4 (where AS data have pretty much stabilized, as indicated by a leveling out of the decreasing trend seen in Fig. 11), the mean percent of F responding for IS sessions was 8.4%. It was 16.2% for RS sessions, almost double that for IS sessions. Those Block #4 figures are to be contrasted with the F responding for Subject #25 during the preceding LT block: the mean percent of F responses was 1.3% for IS sessions and 0.0% for RS sessions.

Given the premise that the use of the forward response mode is the most sensitive indicator(of the four modes) of the study strategy being used, the differences in F responding controlled by the two tape structures constitute some of the most dramatic evidence that AS tapes are more likely to result in an interactive, content-selective strategy, as contrasted with a passive study strategy during the study of LT tapes.

Certainly, from our analysis of the experimentally-produced differences

in F responding, one would predict that there must have been comparable differences for the level of responding in the rewind mode, and that indeed was the case. The following comparisons are mean figures for Block #3 (LT) vs Block #4 (AS) for Subject #25. They are all statistically significant differences:

1)Number of R responses -- Block #3 = 38; Block #4 = 149.

2)Number of IS R responses -- Block #3 = 36; Block #4 = 124.

3)Number of RS R responses -- Block #3 = 2.2; Block #4 = 23.5.

In addition, comparisons of the percent of R responses and the rate of R responses, for both IS and RS sessions, all showed highly significant differences for the two tape structures. Thus, we can summarize the data on both forward and rewind activity levels for Subject #25 as follows:

> for all number-of-response measures of F and R response activity -- both absolute and relative -- AS tapes generated significantly higher levels of responding than did LT tapes.

That these differences in study activity are the result of the fact that Subject #25, for the most part, employed different study strategies for the two tape structures is clear, *for a consistently interactive study strategy applied to LT tapes would produce just the opposite of the above generalization -- i.e., more F and R activity for LT tapes than for AS tapes*. Why so? Because, as we have said, study interaction with AS tapes is much more effecient than with LT tapes. If, during study interaction, AS tapes allow the subject to search and locate relatively quickly, with fewer operations per search, then interaction with the LT structure which presents the subject with lengthy segments of tape to hunt through, will result in a *greater* number of operations per search; and in particular, F, R and P operations. (This fact will become more clear when we discuss the data for individual study sessions.)

This is, in fact, precisely what made the data for Subject #26 different from the performance of Subject #25. He employed the interactive study strategy with

LT tapes as well as with AS tapes, and his overall study activity level was *higher* for the former tape presentation structure than for the latter. Again, however, we will postpone a detailed examination of Subject #26 until we discuss data for individual study sessions.

For Subject #25, the relationships that we have discussed for the F and R modes also hold true for responding in the P mode. That is, the mean number of P responses for AS blocks are significantly greater than for LT blocks by substantial amounts (under 200 vs over 500 for Blocks 1 and 2; and about 100 vs 350 for Blocks 3 and 4). The proportion of P responses is very constant across both blocks for a given tape structure, averaging about 49% for LT study and 52% for AS study.

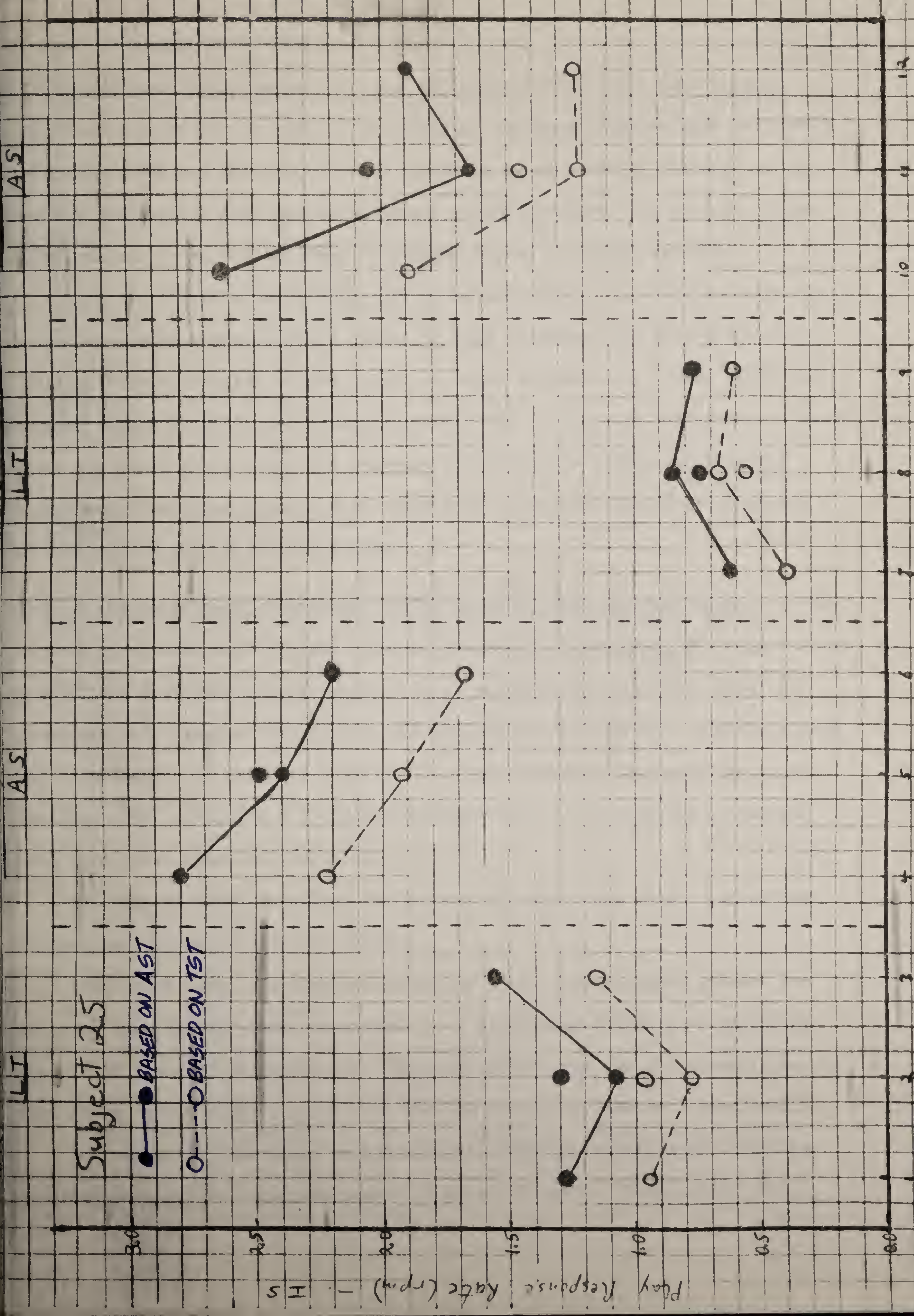
The same relationships for P responding prevailed for both IS and RS sessions, at similar orders of magnitude. In Fig. 12, the P responding during IS sessions for Subject #25 is plotted as response rate. Two response rate measures are shown, *overall* (broken curves) and active (solid). The former is based upon total study time (TST) and the latter on active study time (AST). In this case, the two rate measures are very well correlated. Since the difference between TST and AST is study break time (SBT), the amount of separation between the solid and broken curves of Fig. 12 is directly related to SBT. Or, if there were no SBT, the two curves would coincide.

As with most other measures, both kinds of play rates shown in Fig. 12 have probably stabilized by Blocks 3 and 4. In either case, AS responding is higher than that for LT by factors of greater than 2.0.

The absolute data on how Subject #25 responded on the stop button show the least effect (of the four tape recorder modes) for the experimental conditions, although the differences are still statistically significant at low probability levels (as ascertained by inspection). For example, the mean number of S responses for LT Block #3 was 71 (range: 56 -- 86); for AS Block #4,

Figure Legend

Figure 12. Overall (broken) and active (solid) rates of IS responses occurring in the Play mode. Blocks 1 and 3 show units in which LT tapes were studied. Blocks 2 and 4 are for AS tapes. Data are from Subject #25.


Subject 25
●—● BASED ON AST
O- - -O BASED ON TST
LT
AS
LT
AS
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1
2
3
4
5
6
7
8
9
10
11
12
UNITS
Play Response Rate (rpm) — HS

FIGURE#12

it was 114 (range: 94 -- 131).

Proportionately, however, the use of the stop button was much greater for LT study than for AS study. For example, the mean relative stop responding for Subject #25 was 34% of the total responses in LT Block #3, whereas it was exactly one-half of that amount (17%) for the AS Block #4. In general, these relations are preserved for stop responding during IS and RS sessions.

For now, there is one other point to be made about the level of responding in the stop mode. The absolute number of stop responses did not change significantly as a function of the number of units studied (i.e., mean differences between Blocks 1 and 3, and between Blocks 2 and 4, were not significant). And since the other three modes did decrease significantly within experimental conditions, the proportion of stop responding increased significantly across AS blocks, and also across LT blocks.

Data on the duration of responding in the separate tape recorder modes. So far, we have considered absolute and relative measures of the number of responses in each of the four tape recoder modes. As we have pointed out, the number of responses and response duration are not necessarily correlated. Depending upon the distribution of response durations, a given response frequency may be associated with a high or a low modal duration (i.e., the cumulative response time in a given tape recorder mode).

The data on modal durations for Subject #25 show some highly significant differences between successive blocks:

1) In the F mode, the absolute amount of time is always much greater for AS tapes (successive block comparisons -- 1 with 2 and 3 with 4 -- differ by factors of 7 and 33 respectively). The same holds true for the percentages of time spent in the F mode, whether or not AST or TST is used as a time base.

Interestingly, there are no significant differences in/mean F mode durations (whether absolute or relative) across AS Blocks 2 and 4. Thus, while the

number of F responses was decreasing significantly during the study of AS tapes (see Blocks 2 and 4 of Fig. 11), both absolute and relative cumulative response time in the forward mode was not decreasing. For example, the mean cumulative F mode/response time for Block #2 was 6.9 min ($\sigma = 2.5$); for Block #4, it was 6.6 min ($\sigma = 0.7$). On the other hand, the significant decrease in the number of F responses seen for the study of LT tapes (see Blocks 1 and 3 of Fig. 11), is accompanied by a significant decrease in both the absolute and relative cumulative response time in the F mode. For example, the mean cumulative response time for the F mode for Block #1 was 1.2 min ($\sigma = 0.8$); for Block #3, it was 0.3 min ($\sigma = 0.2$).

Considering our previous points about why the F mode is the most sensitive indicator of the type of study strategy being employed, these facts constitute strong evidence in favor of our previous assertion that the decreases seen in the level of study activity within experimental conditions represent entirely different processes. Here we see, for example, that the decrease in the number of F responses is not accompanied by a decrease in the amount of time spent in the forward mode, when studying from AS tapes. That is, the amount of study interaction (as inferred from cumulative F time) is not changing with the continued study of AS tapes, but the number of F responses needed to achieve that interaction (i.e., the subject's level of effeciency) is changing across AS units.

The fact that, with the study of LT tapes, the significant decreases in the absolute and relative number of F responses is accompanied by significant decreases in the F mode duration shows that a different process is involved. Here we see a change in study strategy (from largely passive to almost completely passive) resulting in less interaction (as inferred from less F mode duration).

2)The same temporal relations seen for the F mode also hold true for the R mode, although the mean differences between successive blocks are not as

large. They are, however, still highly significant differences, for both absolute and relative measures of modal duration. The mean cumulative duration for the R mode is about twice as long for both AS blocks. There are no significant differences between any block means within either experimental condition.

3)Modal durations for P responding were extremely variable. Within-block LT variance was much higher than AS variance. However, when all six AS units are compared with the six LT units, the absolute amount of time in the P mode is significantly greater for AS tapes. The mean modal durations for LT Blocks 1 and 3 were 157.6 min ($\sigma = 24.0$) and 159.7 min ($\sigma = 44.0$); for AS Blocks 2 and 4, the comparable modal durations were 191.0 ($\sigma = 18.0$) and 177.4 ($\sigma = 9.0$).

It is interesting to note here that the absolute amount of P mode time is probably determined, for the most part, by content difficulty, but not the relative modal durations. Thus there is much less variabilty in the percentage figures for P mode durations. Also, the percent of P mode time is increasing as a function of LT tapes studied and decreasing across AS blocks. By the last two blocks, there is a very substantial difference, the percent of P mode time being significantly higher for LT study than it is for AS study. Thus the proportion of P responding, as measured by modal duration, is increasing with continued study of LT tapes, in stark contrast to the number of P responses, which we have seen to decrease as a function of LT units studied.* And the proportion of P mode duration is higher than that for the study of AS tapes (because with AS tapes, there is relatively more F and R responding).

4)As far as the data on the duration of the stop mode are concerned, there are no differences, for either relative or absolute measures, between successive blocks. The absolute amount of stop time appears to be drifting up with successive blocks, and the difference between the mean cumulative stop times for the first and fourth units is significant. The mean for LT Block #1 is 59.6 min ($\sigma = 7.2$);

---

* The reasons for these changes during LT study will be apparent from Fig. 15.

and for AS Block #4, the mean is 77.3 ($\sigma = 13.2$).

5)When the percent (based upon AST) of modal duration is plotted for IS and RS separately, we find the following relationships to hold for the data fram Subject #25:

a)About 3.7% of active study time (AST) is spent in the forward mode during IS sessions, which is about twice as much time, relatively, as during RS sessions (1.9%). One reason for that significant difference is that searching is probably a lot more efficient during review study (RS) sessions because the subject is a lot more familiar with the content. Also, the subject would not be searching the narrative as often during RS and in IS. There are no significant differences in the mean percent of AST for the F mode during IS vs RS when LT tapes are used.

b)For IS sessions, the relative duration in the R mode is about the same for all four blocks (4% to 5% of AST); and for RS sessions, the percent of R modal duration drops very low for LT tapes (about 1%) and is higher for AS tapes (e.g., 6.5% for Block #2). Thus, as is the case for the F mode (where modal duration was 0.0% for RS sessions), we see in these data one of the most important differences between the AS and LT presentation structures. That is, during independent study in preparation for a test (i.e., RS sessions), there is almost no use of the F or R modes when using LT tapes; in contrast, significant proportions of AST are utilized in both the F and R modes while studying from AS tapes during RS sessions.

c)The percent of AST in the P mode is quite variable for both IS and RS sessions. One generalization which can be made is to say that, for all four blocks, RS sessions use a greater percentage of P time (means vary from 87.3% to 98.2%) than do IS sessions (where means vary from 82.3% to 87.9%). Also, for IS sessions, while the relative amount of time in the P mode is increasing across LT Blocks 1 and 3, it is decreasing across Blocks 2 and 4. Therefore, for the last six units (Blocks 3 and 4), the relative amount of P

mode time is significantly greater for LT (mean = 87.9%) than it is for AS (mean = 82.3%).

d) Active stop time is the cumulative duration of stop times $<$ 30 sec. If we compare the percent of AST in the active stop mode for IS and RS sessions, we find no significant differences between consecutive blocks for either type of study. For all four blocks, however, the percentage of active stop time is significantly greater for IS sessions (mean range = 7.5% to 10.7%) than it is for RS sessions (mean range = 0.4% to 2.2%). This would be expected because more active stop time is needed during IS sessions in order to answer the tape recorded questions for each unit.

When we look at the mean duration of responding (in sec) for each of the four tape recorder modes, we are combining into one statistic the previously described data on numbers of responses with the data on modal durations. Some of the generalizations on mean response duration are as follows:

1) There are no significant differences between block averages for mean F response duration. Unit means were quite variable, and block averages ranged from 3.4 sec to 7.2 sec. The mean duration of F responses was generally higher for IS sessions than for RS sessions.

2) The mean duration of R responses was significantly higher for LT Blocks 1 (4.7 sec) and 3 (9.4 sec) than for AS Blocks 2 (2.9 sec) and 4 (4.3 sec). That is exactly as one would expect since the LT structure involves much greater tape distances than is the case for AS tapes. Interestingly, for both blocks of AS study, the mean duration for R responses is significantly higher for RS sessions than for IS sessions, and it increases substantially across the two blocks of AS tapes. In Block #2, the mean R response duration for IS sessions = 2.3 sec; for RS = 5.6 sec. And for Block #4, the mean R response duration for IS = 3.8 sec; for RS = 6.9 sec. In this case, the longer durations of the R response for both RS (over IS), and for Block #4 (over Block #2), is probably indicative of a greater facility in using the adaptation structure.

Or, to put it another way, when the subject has learned better where target material is located, he can make longer rewind responses during searching activities (and, of course, fewer per search). Thus the mean rate of R responding is significantly less for Block #4 than it is for Block #2, and IS rates of responding are significantly higher than RS rates in all cases, whether the rates are computed upon the basis of AST or TST. For example, in Block #4, the mean (AST) rate of R responding for IS sessions = 0.85 rpm; for RS sessions, the mean (AST) rate of R responding = 0.39 rpm.

3)The mean duration of active (i.e., $<$ 30 sec) stop responses was another variable sensitive to changes in experimental conditions, although it remained fairly constant within experimental conditions. The mean S response durations for LT Blocks 1 and 3 (14.0 sec and 15.8 sec respectively) were significantly higher than for AS Blocks 2 and 4 (10.8 sec and 11.6 sec respectively). There were no consistent differences between IS and RS sessions for the variable of mean duration of active S responses.

4)As would be expected from our discussion of the characteristics of the passive vs the interactive study strategy, there are very substantial differences between experimental conditions for the datum of mean duration of P responses. Figure 13 shows the mean P response duration for IS sessions (open circles), RS sessions (open triangles), and for all study sessions combined, or Total Study (solid curves). The data are from Subject #25.

In all cases, the mean duration of P responding is much greater for LT study than it is for AS study. As we shall show, one of the main ways in which AS tapes produce a different study performance from that of LT tapes is described by this variable of duration of P responding.

It may be seen from Fig. 13 that, for LT Block #1, the mean P response duration (solid curve) of 52.5 sec is over twice the value for AS Block #2, where the mean is only 23.2 sec. For LT Block #3, the mean P response duration

Figure Legend

Figure 13. Mean duration of Play responses for Total Study (solid curves), IS sessions (open circles), and RS sessions (open triangles). Blocks 1 and 3 show units in which LT tapes were studied. Blocks 2 and 4 are for AS tapes. Unconnected points show block means. Data are from Subject #25.

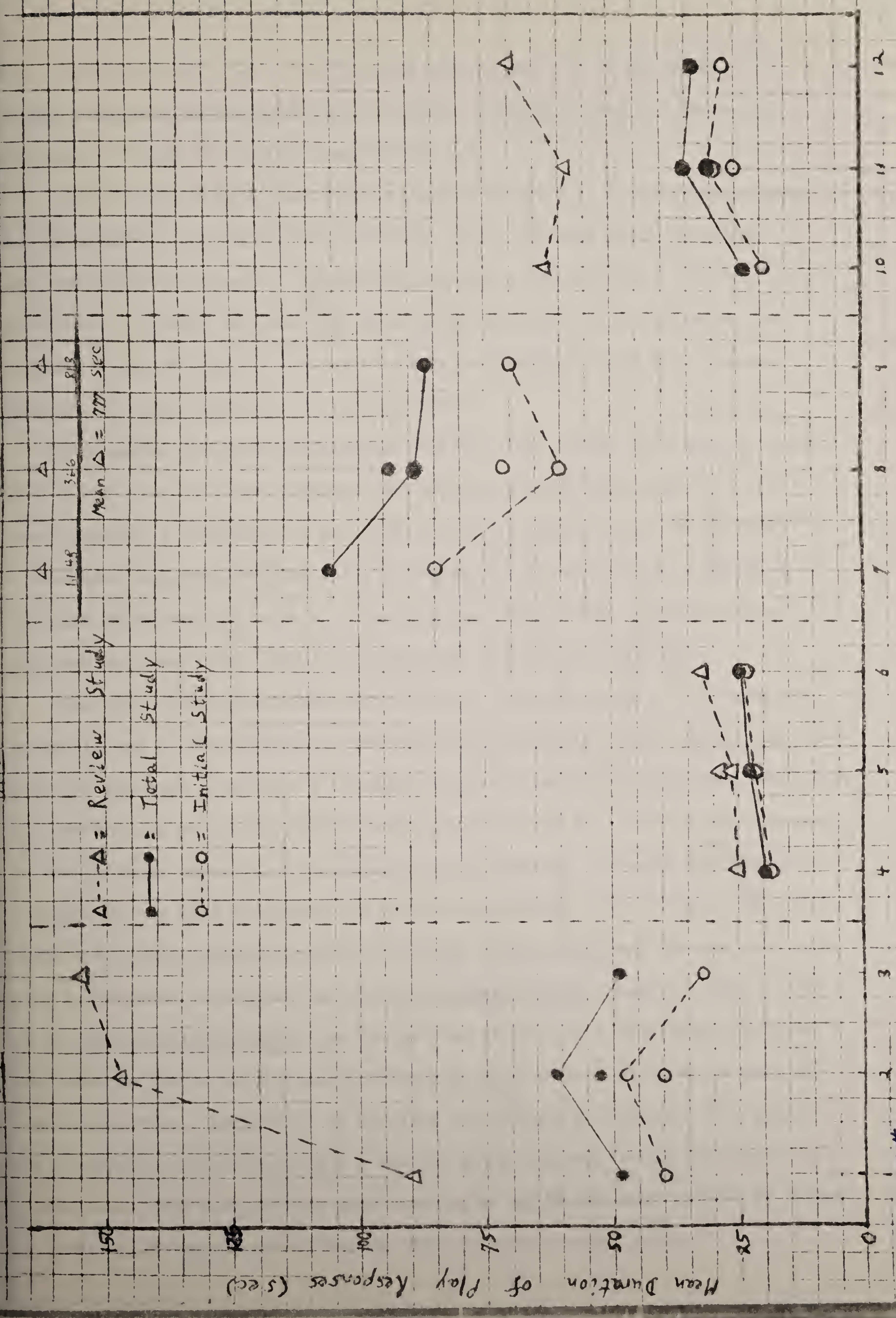

L|T
A|S
L|T
A|S
Δ--Δ = Review Study
●—● = Total Study
○--○ = Initial Study
11.48
3.66
8.18
Mean Δ = 7.77 sec
Mean Duration of Play Responses (sec)
0
25
50
75
100
125
150
1
2
3
4
5
6
7
8
9
10
11
12

FIGURE #13

has increased to 94.1 sec, almost double what it was for LT Block #1, and larger than that for AS Block #4 by a factor of greater than 3. The mean P duration for Block #4 remains low, at 30.4 sec.

For all four blocks, the mean P response duration is significantly lower for IS sessions (open circles) than it is for RS sessions (open triangles), and the IS/RS difference is significantly greater for LT blocks than it is for AS blocks. In fact, the mean for RS sessions in Block #3 is way beyond the ordinate scale of Fig. 13 at almost 13 min (as compared to an RS P response duration of about one minute for AS Block #4).

Here again, the IS/RS differences for the study of AS tapes are the result of the fact that RS study involves less searching activities which utilize short-duration P responses on the order of two to ten seconds. These short P responses intervene between R and F responses for the purpose of checking the tape while zeroing in on a target passage, and so they bring the mean P response duration lower down for IS sessions than for RS sessions.

The huge IS/RS differences seen in Fig. 13 for the study of LT tapes are, as usual, due to the different study strategies employed for IS and RS sessions. Thus the extremely high mean P response durations for RS sessions are a reflection of a more (sic) passive study strategy during RS than IS. And the same change in the relative emphasis of the passive study strategy accounts for the large increase in the mean P response duration from LT Block #1 to LT Block #3. Thus, while the passive/interactive study strategy distinction may, for the most part, be a dichotomous distinction at the study session level, once you look at data on the unit or block levels, the distinction stands for a continuum, and study performances can be scaled quantitatively as more or less passive, or more or less interactive. Therefore, in the case of the/LT data for Subject #25, all of his P response durations reflect a passive study strategy (relative to his AS performance), but his study is more passive during RS sessions than it is during IS sessions, an extraordinary finding which we will discuss below.

Although all of the mean differences between experimental conditions shown in Fig. 13 are very large (and, by inspection, significant at very low probability levels), the data as plotted do not begin to reflect the true play-duration differences between study with AS tapes and study with LT tapes. That is because study with LT tapes almost always involves some short-duration P responses which lower the mean duration. However, there is a much more revealing way of representing the P duration data, and that is a comparison of the relative distributions of P response durations for AS and LT tapes. Thus, the relative distributions of P response durations seen in Fig. 14 provide a dramatic picture of how different the study performances are.

In Fig. 14, the solid curve is for the study of LT tapes and the broken curve is for the study of AS tapes. The data are from Subject #25. Each distribution is plotted as percentages of play time cumulated for all six units (IS and RS sessions combined). What is seen in Fig. 14 may well be the most important kind of study performance differences produced by the AS and LT forms of tape recorded presentation.

It may be seen from an inspection of the broken curve that throughout the study of six units of AS tapes, an uninterrupted play duration of greater than five minutes almost never occured. That is not a necessary finding, but it is not surprising when it is remembered that, in Exp. III, the narrative material (exposition and commentary)of AS tapes never exceeded five minutes. So the sharply negatively accelerated, decreasing function for AS study seen in Fig. 14 is a reflection of the fact that the properties of the adaptation structure exerted a strong control over the listening activities of Subject #25.

But what happens when the aural learner is allowed access to long, uninterrupted portions of narrative, as with the LT tape presentation version used in Exp. III? The solid curve in Fig. 14, showing data for Blocks 1 and 3 combined, provides us with an answer which is in dramatic contrast to the

Figure Legend

Figure 14. Distributions of Play response durations, expressed as the percent of total play time. Both curves are for Total Study (IS and RS sessions combined). The solid curve is for study with LT tapes (Blocks 1 and 3 combined) and the broken curve is the distribution for AS tapes (Blocks 2 and 4 combined). Data are from Subject #25.

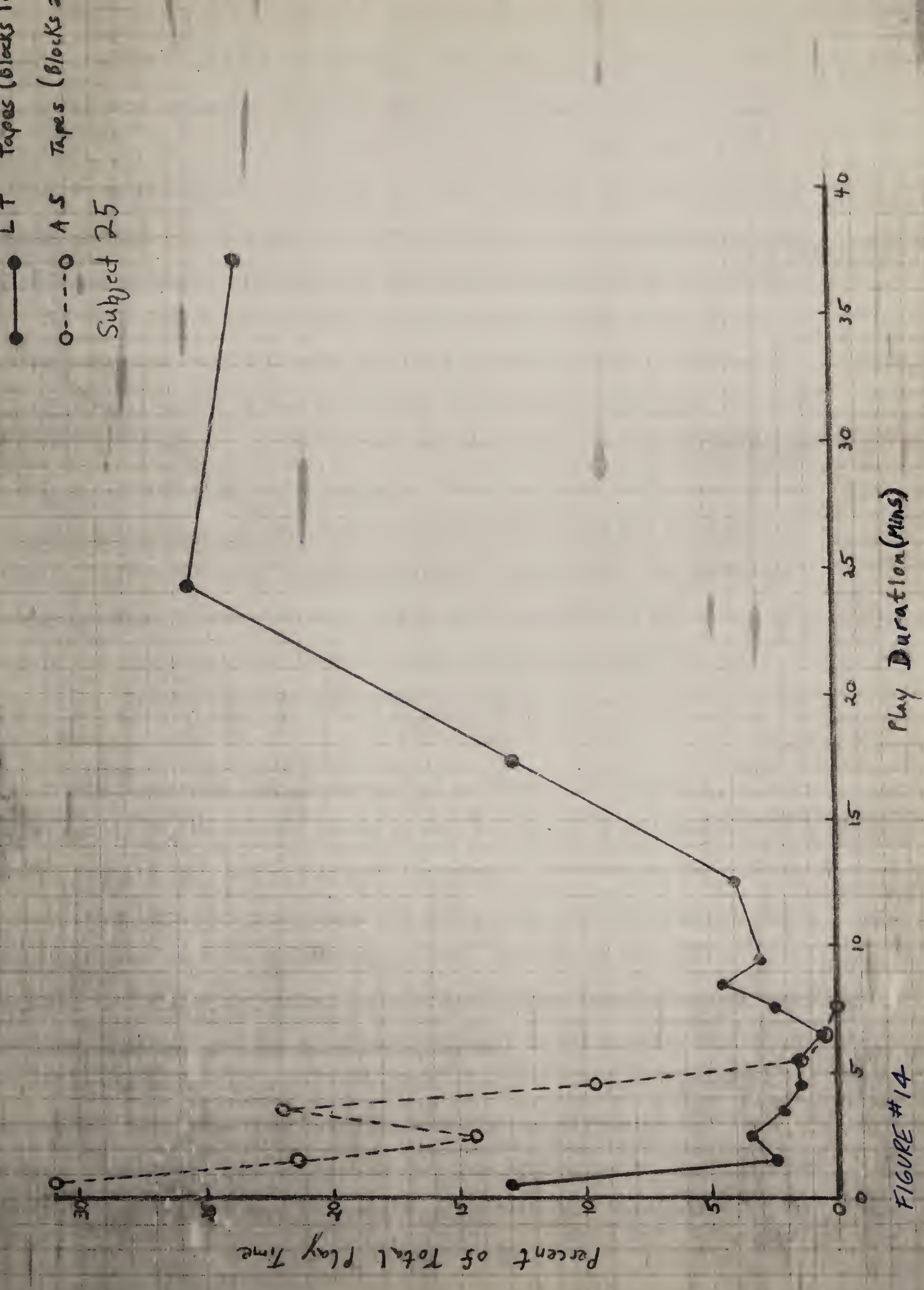

●——● L T Tapes (Blocks 1 and 3
o- - -o A S Tapes (Blocks 2 and
Subject 25
Percent of Total Play Time
0
5
10
15
20
25
30
Play Duration (MINS)
0
5
10
15
20
25
30
35
40

FIGURE #14

distribution for Blocks 2 and 4 combined. The solid curve is a picture of one of the main properties of the passive study strategy -- long P response durations. The curve shows that while studying with LT tapes, most of the subject's listening time is accounted for with P response durations exceeding 15 min. Indeed, it may be seen from the distribution that uninterrupted play durations exceeding one-half hour are not atypical for the study of LT tapes.

The two relative distributions of play durations shown in Fig. 14 demonstrate that the subject is studying the two kinds of tapes in totally different ways, merely because the content of AS units is structured differently from that of LT units(i.e., the differences seen in Fig. 14 are not controlled at all by differences in verbal content). Given such huge differences in the way Subject #25 spent his study time, one would expect that one of those two learning performances would be more beneficial than the other, as manifested in some measures of comprehension. Or, to put it another way, it is hard to believe that such completely different study performances could be equally effective in leading to comprehension and retention. As we shall see, they are not.

The solid curve of Fig. 14 showing the relative distribution of play durations for the LT blocks might not be of much concern to us as educators if it were true that the subject had been listening to, for example, literal transcription tapes of a good novel. In such a case, the solid curve of Fig. 14 is just about what one would expect to see. But that is not the case here. The content of all of the ecology tapes in Exp. III was technical science material which was admittedly unfamiliar to both subjects. It was material which is not effectively understood with continuous play durations exceeding 15 minutes. Intuitively, the passive study strategy which Subject #25 employed with the LT tapes -- the strategy which yielded such high percentages of long P response durations -- is not the most appropriate way to learn such material.

That conclusion is all the more compelling when one considers a fact about the momentary availability of content on tape which was briefly discussed in the introduction to this report (see page 2); namely, that one major disadvantage in learning from a tape recording (as contrasted with reading the textbook from which the tape was made) is that the student is forced to rely much more heavily upon the short-term memory of what has recently been heard. By its very nature, short-term memory functions for small amounts of input. That is, it is easily overloaded. Surely, the solid curve of Fig. 14 is an example of such overloading.

Throughout our presentation of the results of Exp III, we have seen examples of statistically significant study performance changes occuring across the blocks for a given tape structure. Such changes occur for both tape structures, as is seen, for example, in the decreases in the overall study activity levels across both LT blocks and AS blocks in Figs. 9 and 10. And each time we have discussed such changes, we have pointed out that they represent two different processes -- a "practice effect" for the study of AS tapes, as opposed to a shift in study strategy for the two LT blocks. Thus, while Subject #25 was getting more and more efficient at interacting with AS tapes, he was also doing less and less interacting with LT tapes.

Figure 15 is still more evidence in support of the proposition that the latter process is, indeed, occuring. Here, the LT data for the relative distributions presented in the previous graph (the solid curve of Fig. 14) are presented for each block of units separately. It may be seen that initially (i.e., in LT Block #1), Subject #25 engaged in a more (sic) interactive study strategy with LT tpaes, as evidenced by the fact that, relative to the broken curve for LT Block #3, there were more short-duration P responses and fewer long P durations. The solid curve, generally speaking, shows passive study, but there is evidence that the subject is trying to interact with the LT tape. The broken curve,

Figure Legend

Figure 15. Distribution of Play durations expressed as the percent of total Play time. Both curves are for total study (IS and RS sessions combined) of LT tapes. The solid curve is for Block #1 (Units 1 -- 3) and the broken curve shows LT study for Block #3 (Units 7 -- 9). Data are from Subject #25.

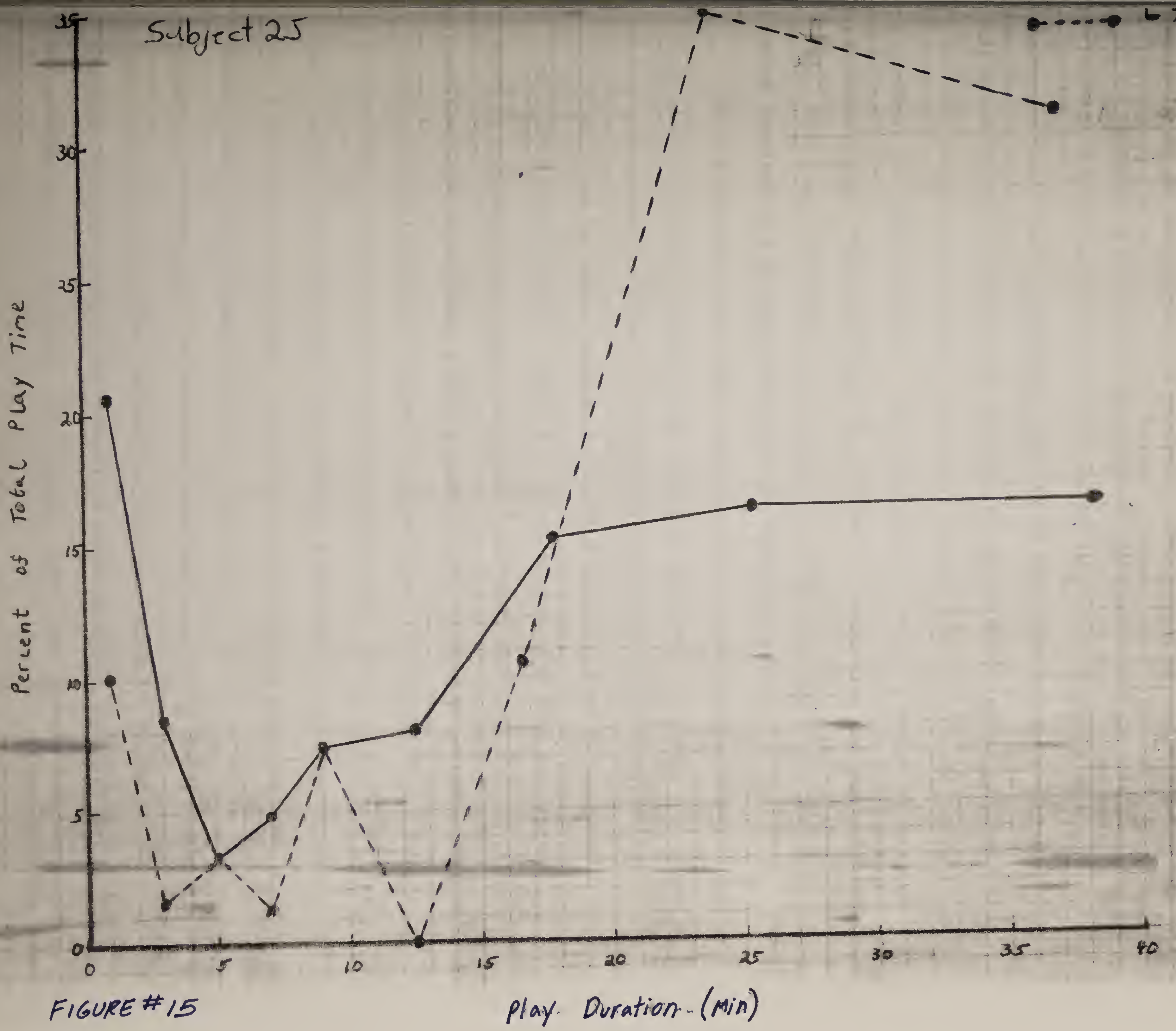

Subject 25
●----● LT Tapes (Block 3)
Percent of Total Play Time
0
5
10
15
20
25
30
35
0
5
10
15
20
25
30
35
40
Play Duration (min)

FIGURE #15

however, shows that the subject has just about given up trying. Over 75% of the total Play time for Block #3 is taken up with P durations exceeding 15 min. And about 88% of all Play time occured for P durations of greater than five minutes (which may be contrasted with the AS curve in Fig. 14, where almost 100% of all Play time occured for P durations of less than five minutes).

Thus Fig. 15 adds strong support to the many other graphs we have constructed which show a progressive shift in LT study performance -- a change from a moderatedly passive study strategy to an extremely passive performance. And that change is not because the subject "learns better" with the more passive strategy, but rather because the experience of trying to engage in an interactive strategy while studying from LT tapes is unrewarding and highly frustrating. That fact will become very evident from some data samples of individual study sessions with LT tapes which will be presented below.

We have mentioned that while studying with LT tapes, the performance was more passive during RS sessions than during IS sessions. At first, that seemed to be a paradoxical finding for, if interaction with LT tapes is especially difficult, then why should interaction be at a minimum during RS sessions, just before testing occurs? After all, it is at that time when independent study is presumably most highly motivated; and also, the aural learner is more familiar (from IS sessions) with the general tape location of content. Both of those considerations would lead one to suspect just the reverse of our data -- a higher level of interaction during RS sessions than during IS sessions. The data, however, are unequivicol, not only for Subject #25, but also for Subject #26. With few exceptions, "review" for a test with LT tapes consists of uninterrupted re-listenings to all or a large portion of the narrative of an LT tape. Interestingly, the review and question items at the end of the LT tape are typically not even listened to, much less responded to, during RS sessions, even when many of the answers to those questions, recorded during IS sessions, were not correct. In contrast, those items (review and questions)

Figure Legend

Figure 16. Distribution of play durations expressed as the percent of the total play time. All four curves are for the study of LT tapes. The solid curves show study during Block #1 and the broken curves are for Block #3. Filled points are for IS sessions and open points are for RS sessions. Data are from Subject #25.

Subject 25

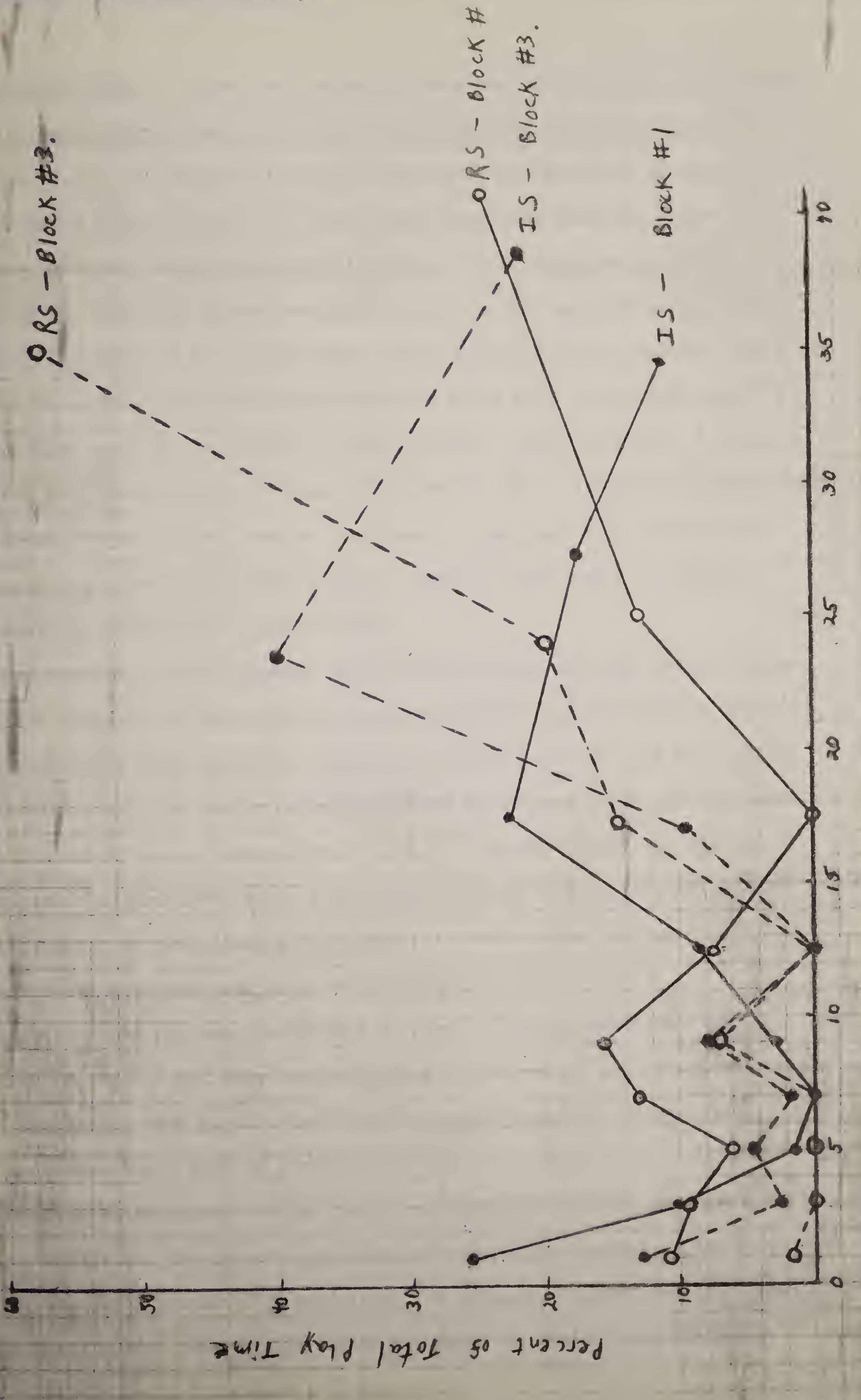


FIGURE # 16

are the primary focus of attention during RS sessions with AS tapes, indicating that their neglect during study with LT tapes is not the subject's choice. Interactive study with AS tapes is highly selective, the subjects returning to the narrative after listening to particular review and question items.

Figure 16 shows the relative distributions of play durations for four separate cases. All four curves are for the study of LT tapes by Subject #25. The two solid curves are for IS sessions (filled points) and RS sessions (open points) of Block #1. The broken curves are for Block #3. It is clear from the figure that most of the interaction (as inferred from the shorter P durations) occured for the IS sessions. In fact, the curve for RS -- Block #3 (broken/open points) shows almost no play time at durations of less than five consecutive minutes; and over one-half of the total play time for that curve is taken up with P durations of more than one-half hour.

Having examined several samples of individual study sessions with LT tapes, however, the reasons for interaction during IS sessions and the lack of it during RS sessions are quite apparent. They concern the fact that, as part of the procedure of Exp III, the subjects were required to respond to all of the questions at the end of the LT tapes (even if only to indicate that they did not know the answer to the question). This requirement was always fullfilled during IS sessions. We will discuss this matter in detail when the data for individual study sessions come under consideration.

Figure 17 shows the same parameters as Fig. 16, except here they are plotted for AS tapes. Not only are the shapes of the curves entirely different, but the reader should also note that the scale range on the abscissa is less than one-fourth that of Fig. 16.

Again, the solid curves are for the first block of AS study, and the broken curves are for the second. In spite of very large changes in the level-of-activity measures across AS blocks (see, for example, Figs. 9 and 10), there is not much difference between the curves for Block #2 (solid) and Block #4

Figure Legend

Figure 17. Distribution of play durations expressed as the percent of total play time. All four curves are for the study of AS tapes. The solid curves show study during Block #2 (Units 4 -- 6) and the broken curves are for Block #3 (Units 10 -- 12). Filled points are for IS sessions and open points are for RS sessions. Data are from Subject #25.

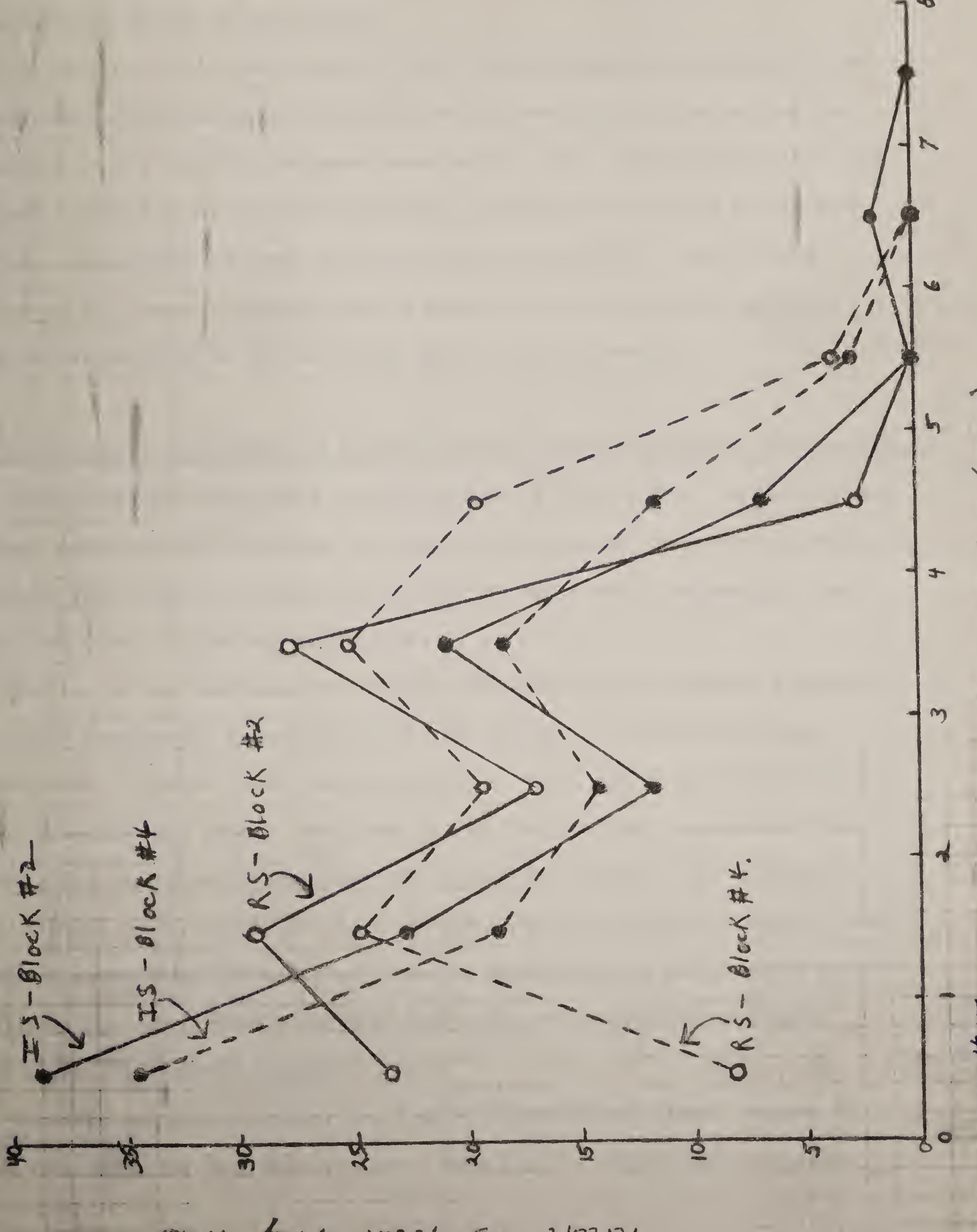

IS-Block #2
IS-Block #4
RS-Block #2
RS-Block #4.
Percent of Total Play Time.
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
Play Duration (Mins).

FIGURE #17

(broken) in Fig. 17. That is in stark contrast to the large performance change across blocks seen in Fig. 16. Thus, with continued study of AS tapes, there is a large change in the level of activity (reflecting more efficient study), but not in the amount of interaction.

The fact that all four curves of Fig. 17 are bi-modal is probably related to the itemized and narrative properties of the adaptation structure and the parameters of the listening segments used in Exp. III. Specifically, LS's were composed of quite short items of less than one minute in duration and larger portions of narrative of three to four minutes in duration. That is, the M-shape of the curves suggests that the subject is using both the narrative and itemized portions of the LS during both IS and RS sessions.

Data on the study performance of Subject #26 and data on individual study sessions.

So far, we have emphasized the performance of Subject #25. We have, along the way, indicated that the data for Subject #26 are, on the one hand, quite different from those of Subject #25, and on the other hand, corroborate them. We are now ready to show why that is so.

In Fig. 18 are some data from Subject #26 which may be compared directly with their counterpart from Subject #25 seen in Fig. 9. Both figures show two measures of overall study activity level -- total number of responses and active response rate (rpm). Note that in Fig. 18, the block sequence of tape presentation structures is reversed for Subject #26, Blocks 1 and 3 showing study with AS tapes, and Blocks 2 and 4 representing study with LT tapes. Thus, in making comparisons between Figs. 9 and 18 appropriate to performances generated under the same presentation structure, odd- and even-numbered blocks should always be compared together.

Consider the study activity level under AS conditions first. Figure 18 shows data which are very much in accord with Fig. 9. Significant decreases

Figure Legend

Figure 18. Total number of tape recorder responses (solid curve) and active response rate (broken curve) for the two block conditions of tape presentation structure. Blocks 1 and 3 show data for the study of AS tapes. Blocks 2 and 4 are for the study of LT tapes. Unconnected points show block means. Data are from Subject #26.

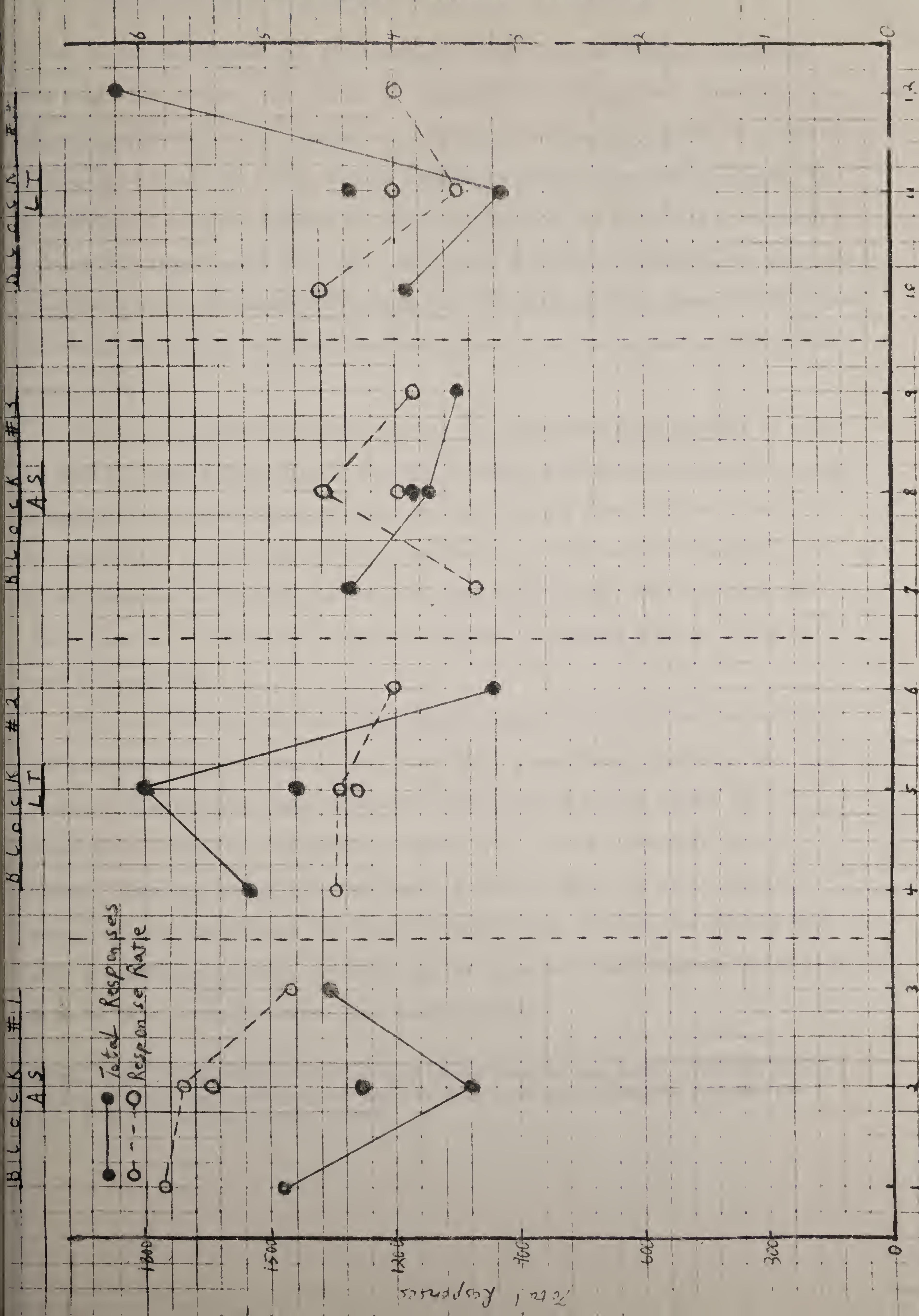

Active Response Rate (rpm).
0
1
2
3
4
5
6
BLOCK #1
AS
BLOCK #2
LT
BLOCK #3
AS
BLOCK #4
LT
●—● Total Responses
○- - -○ Response Rate
1
2
3
4
5
6
7
8
9
10
11
12
UNITS
0
300
600
900
1200
1500
1800
Total Responses

FIGURE #18

occur in the mean values for both measures across the AS blocks, indicating the same kind of "practice effect" we have seen for Subject #25. Even the values themselves are very comparable. Although the activity level is slightly higher for Subject #26, that is only because he usually used the stop mode for a fraction of a second between the P and R responses, or the P and F responses.* Subject #25 almost never did that. When those brief stop responses are subtracted from the overall responding of Subject #26, his data on total number of responses and response rate for AS tapes come very close to the corresponding mean values seen in Fig. 9.

That is, as reflected in the data of Fig. 18, Subject #26 studied AS tapes in much the same way as Subject #25 did -- with a consistently interactive study strategy. That generalization holds not only for the data of Figs. 9 and 18, but generally, for all the levels of analysis for which we have looked at the AS performances of both of the subjects used in Exp. III. That is, both subjects continued to use the interactive strategy throughout both AS blocks in much the same way.

The similarities just mentioned between Figs. 9 and 18 do not extend to the corresponding LT blocks (1 and 3 for Fig. 9, and 2 and 4 for Fig. 18). Instead of significantly lower levels of study activity for LT study, Fig. 18 shows levels which are comparable to those for AS tapes throughout both LT blocks. From our analysis so far, it is a good bet that the high, overall study activity levels seen for the LT blocks of Fig. 18 mean that Subject #26 used the interactive study strategy with LT tapes much more than did Subject #25. Figures 19 -- 23 will confirm that interpretation.

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*Note: With the modified APH play-back decks used in our aural learning laboratory, it was not necessary to use the stop mode when changing between the P and R modes, or the P and F modes.

The five figures just mentioned are considered as a group for they constitute five complete records of Subject #26 studying LT Unit #12. Each figure shows a different study session -- four successive IS sessions followed by one RS session. Every operation of the tape recorder which was made during the study of Unit #12 is shown in the five records -- a total of 1860 responses. Clearly, Subject #26 must have used an interactive study strategy at *some* point during the study of Unit #12.

Indeed he did, but not, however, in the first IS session seen in Fig. 19, which is illustrative of a typical case of the use of the passive study strategy with an LT tape. Here, as in the succeeding four graphs, tape location (in cm from point zero) is plotted as a function of study time. The sequence of LT sections (beginning with the *contents* section) is indicated in the body of the figure (see Fig. 6 for a diagram of the LT version of Unit #12). The positive slope shows study in the *Play* mode, the negative slope is *Rewind*, and the zero slope is the *Stop* mode. (The *Forward* mode is not represented in Fig. 19 -- a not uncommon fact in the extreme case of the passive study strategy -- but is seen, as in Fig. 20, as a positive slope greater than that of the play mode.)

In the first IS session of just over one hour depicted in Fig. 19, a total of only 17 operations of the tape recorder occurred. None of those responses involved selective interaction. Thus the study session is a very simple one to describe: the subject listened, in an essentially uninterrupted fashion, to the contents, narrative, summary, and review sections, after which he immediately rewound the tape recorder to point zero and re-listened, non-selectively, to the contents and almost all of the narrative.

The IS session shown in Fig. 19 was followed, on the morning of the next day, by a second IS session, which is shown in Fig. 20. Initially, the subject's performance is essentially a replication of the first 40 minutes of the

Figure Legend

Figure 19. Individual study session with an LT tape for Subject #26. Tape location throughout the first IS session of Unit #12 (in cm from a zero tape-beginning point) is plotted as a function of study time (in minutes). The LT tape sections are indicated in the body of the figure. The performance shown is a very typical example of employing the passive study strategy.

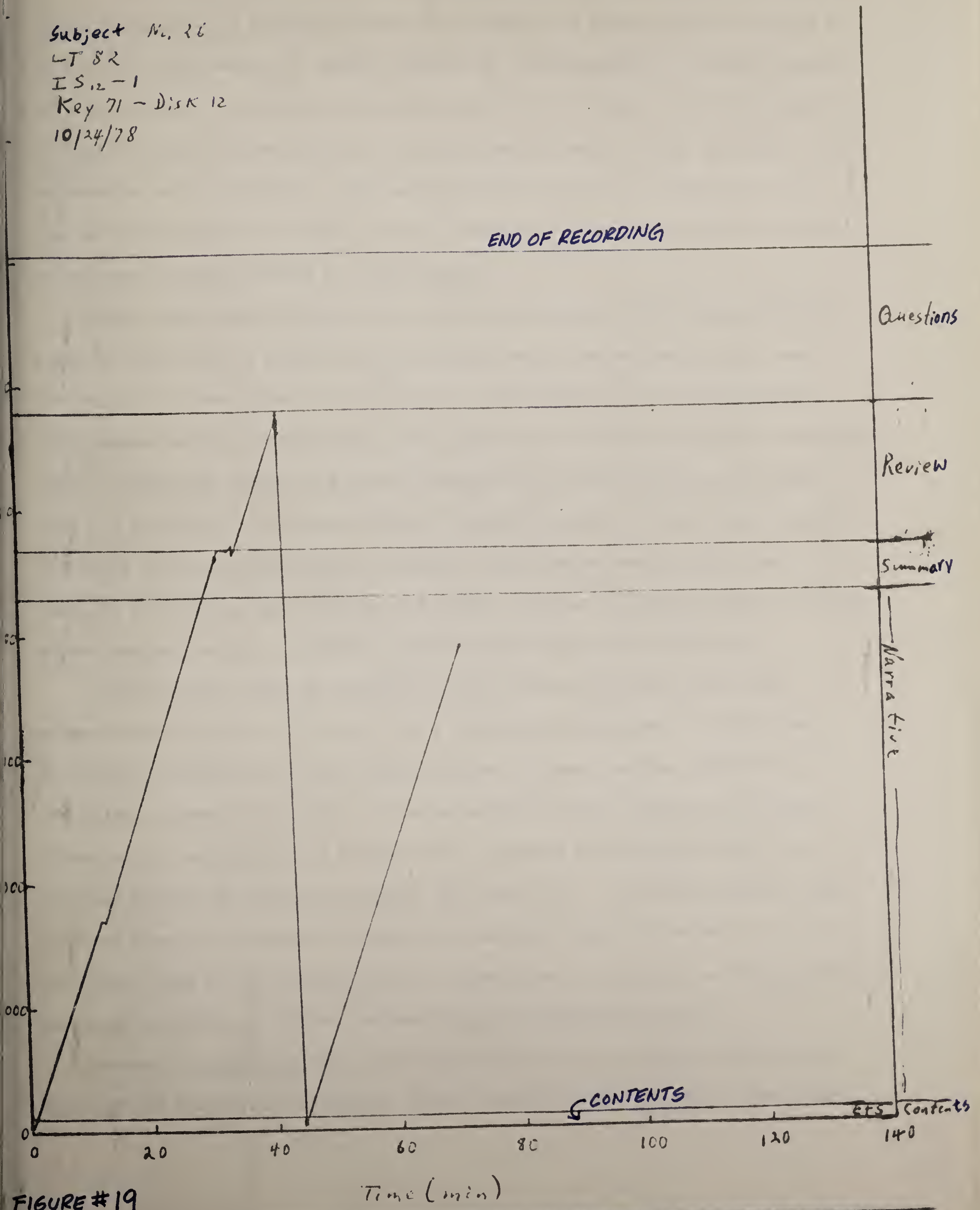
Subject No. 26
LT 82
IS_{12}-1
Key 71 - Disk 12
10/24/78

FIGURE #19

previous IS session: one long, uninterrupted period of listening (or rather re-listening) to the contents, narrative, summary and review sections (arrow a in Fig. 20), followed by a rewind response to the beginning of the tape (arrow b). In contrast to the first IS session, however, the first rewind at arrow b in Fig. 20 marks the beginning of a shift from the passive study strategy to an interactive study strategy. This pattern of starting out the study of an LT tape with the passive strategy and then switching to the interactive is typical of all the LT units studied by this subject.

Before describing further the performance of Subject #26 studying the LT tapes of Unit #12, we should say some things about that particular unit and the subject's preparation for studying it. The author of the ecology course (the present writer) deliberately wrote the unit at the most difficult conceptual level. From exam scores and several measures of study activity performance, Unit #12 proved to be the most difficult of all 12 units of the ecology course for this, as well as most other, subjects. (The reader should note from Table 1 that, in addition to the subjects of Exp III, 13 other subjects studied the same course content in Exp I, where LS length was the independent variable.)

Another point about the concepts of Unit #12 is that they were quite sequentially dependent. That is, one's ability to understand a given idea in the unit depended very much upon the level of understanding achieved on preceding concepts in the unit. From an analysis of the answers to the questions in the last section of LT tape #12 -- answers which Subject #26 tape recorded during the fourth IS session (see Fig. 22) -- it is clear that he was confused about the meaning of several of the basic ideas in the unit. It is also clear that he was confused from an inspection of his study activity performance on Unit #12, as will be obvious from the presentation below.

However, in spite of the extra conceptual difficulty of Unit #12, and in spite of the sequential dependency of the concepts, Figs. 19 and 20 show that

Figure Legend

Figure 20. Individual study session with an LT tape for Subject #26. Tape location is shown as a function of study time for the second IS session of Unit #12. The session starts out with the passive study strategy and then changes to the interactive study strategy.

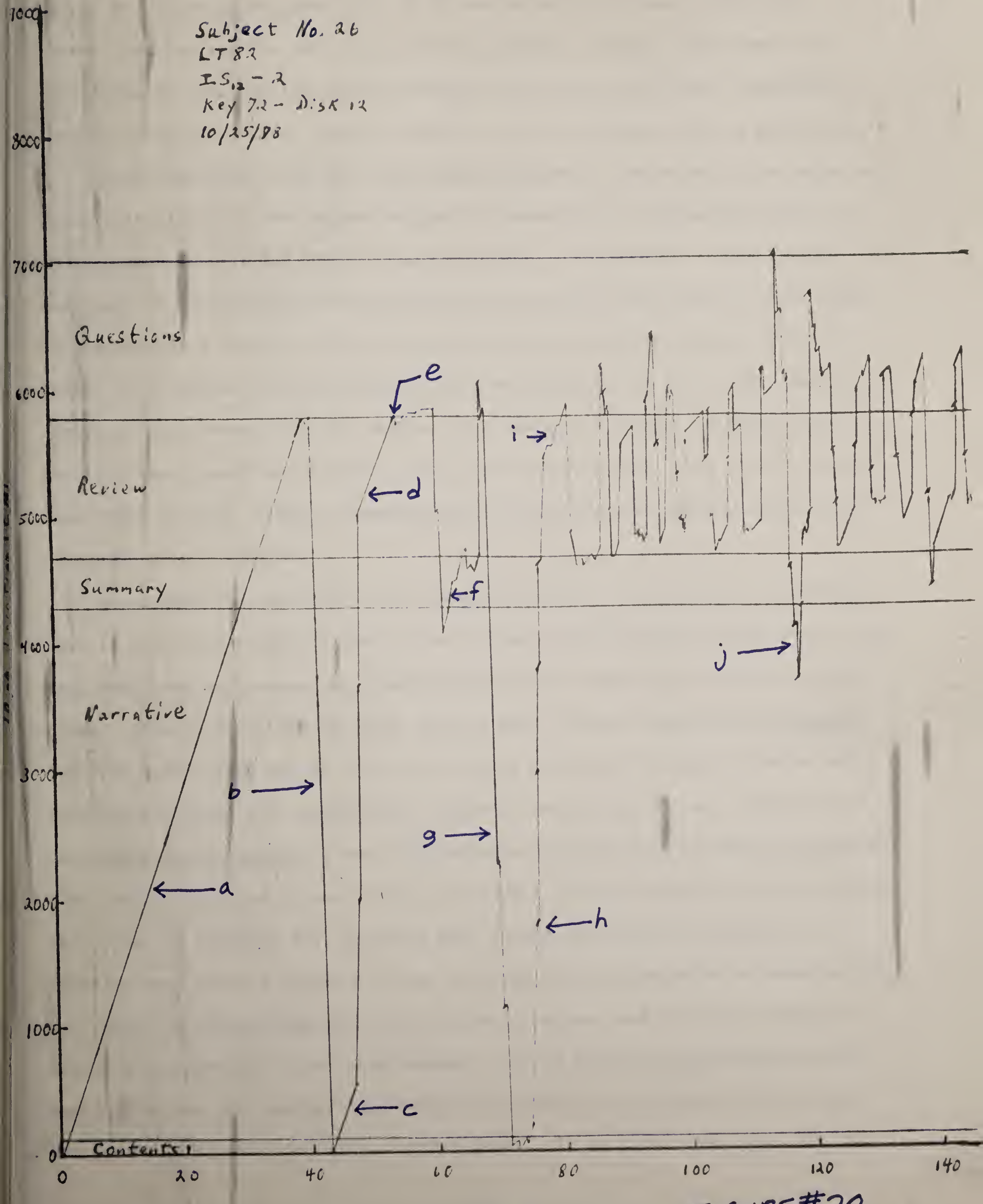
Subject No. 26
LT82
IS_{12} - 2
Key 7.2 - Disk 12
10/25/88

FIGURE #20

Subject #26 began studying this LT tape (much as in the case of the other LT tapes) by listening to almost all of it non-selectively three consecutive times. Considering the difficulty of the material, the play durations characteristic of this passive study strategy were, to say the least, excessively long for effective study. Again, Unit #12 was not a chapter from a good novel.

As we mentioned, with the long rewind response to the start of the tape (at arrow b in Fig. 20), the subject begins LT interaction. Interacting with the LT structure used in Exp III is always, at best, a compromise. Ideally, the most helpful explication for any question at the end of the tape is to be found in the narrative section. It is true that _if_ the narrative has been understood, re-listening to the corresponding generalization in the review section would, in many cases, help the subject to formulate a correct response to a question about which he is unsure. But, for the most part, that is only true when there is good, general comprehension of the narrative material which corresponds to the question.

But finding the material in the narrative which corresponds to a question item is much more difficult than it is to find a corresponding review item. For one, much less tape separates questions and review items which relate to each other. Also, because the LT tapes used in Exp. III were constructed _verbatum_ from the material of the AS tapes, both types of itemized content (review and question sections) are numbered, and there is (as an intentional property of our _adaptation structure_) a very high correlation between the numbers associated with the two types of items. Thus, for example, if the subject is unclear about the answer to question #10, he knows that review item #10 is recorded at a location near which a review item may be found which corresponds to question #10.

Thus, in interacting with the LT tape structure used here, the subject is forced to choose one of two alternatives, both of which are compromises: good explanation but poor access (searching the narrative); or better (sic) access but poor explication (locating a review item). It is clear from Figs. 20, 21,

and 22 (IS sessions 2, 3, and 4, respectively) that Subject #26 chose the latter interaction alternative most of the time. That is, almost all of his LT interaction is a going-back-and-forth between question and review items.

Interestingly, most blind students do not have the question-review interaction option available to Subject #26, at least it is not as extensive and well structured as it is here. As we pointed out earlier (see p. 37), few textbooks contain as many well-correlated question and review items at the end of chapters as exist for the LT tapes of Exp III.

Returning to an inspection of Fig. 20, it may be seen that the first interaction is an exception to the rule, for it is an excursion back into the narrative. Just prior to the rewind response at arrow b, Subject #26 listened, for the first time, to question #1. Since it is the first question, narrative material corresponding to it would most likely be found at the start of the narrative section. And, of all locations in the narrative, that is the easiest part of section to locate, for it is very near to the start of the tape. So we see in Fig. 20 that Subject #26 takes advantage of that unique reference point and rewinds to the beginning of the tape. It is a long rewind, but is made in spite of the obvious fact that his study intention is to return back to the question section as soon as he has listened to narrative explication (*a search-return cycle*).

After re-listening to the table of contents in its entirety (for the *forth* time), presumably while holding question #1 in mind as best as possible, a small section of the beginning of the narrative is re-listened to (at arrow c) Then the subject returns to question #1 by using the F mode up to a point well short of his target (which we call *undershooting the target* which, along with its complement, *overshooting*, is an enormous consumer of time during the study of LT tapes as may be seen in Figs. 20 -- 22), after which the P mode is used for *several minutes* (arrow d) before reaching the question section again (arrow

e). That marks the end of the first LT interaction episode. Relative to the rest of the search-return cycles seen in Fig 20, that initial one was probably the most successful: target material which would explicate the question was located, and the target material was the most appropriate kind (ie, it was narrative rather than review content).

Although successful from those standpoints, the first search-return interaction cycle was not a very efficient one. Much of the time was spent in listening to inappropriate material(e.g., the first part of the P response at c, and all of the P response at d). The entire cycle took more than 13 minutes of study time. The rest of the study session involves search-return cycles which are alternations between the question and review sections. At best, there are (depending upon how you define them) 15 such search-return cycles which occur from arrow e to the end of the IS session depicted in Fig. 20. Those cycles occur in about 95 minutes of study time, for a rate of about 0.16 cycles per minute, or one search-return cycle for every 6.3 minutes on the average. That is, in over one and one-half hours of time, Subject #26 attempted to relate, perhaps, 10 to 15 questions to other material which might provide explication. There is no way of telling, from this record, how successful those attempts were in terms of locating material which was relevant to the questions from which the search-return cycles originated. It is clear, however, that much P-mode time is spent listening to irrelevant material. Examples are seen at arrows f and i, and especially d. Such irrelevant listening episodes are another example of the subject making a compromise during LT interaction. In any search for target material, the use of the P mode precludes the problems of overshooting and undershooting (which generally occur only during the F and R responses), but it consumes minutes of study time and is distracting because it generally involves irrelevant material.

In the only other deliberate search of the narrative seen in Fig. 20, the subject made several P, R and F responses in a search for a target passage (see arrows g and h). It is very doubtful if the target material was located in this instance. The whole search-return cycle, however, consumed more than 14 minutes of study time, an effort which would have required seconds to accomplish successfully for a sighted student reading from a textbook. It is, thus, no wonder that searching the narrative of an LT tape does not occur very often. It is a terribly cumbersome business and often ends up unsuccessfully. It is clear from Fig. 20 that just searching the review section from the question section takes a lot of effort and patience. Undershooting and overshooting in making F and R responses (as at arrows i and j) is a common occurrence which is usually very costly in terms of recovery time, not even to dwell upon the subjective psychological variable of frustration.

If we consider the LT interaction which begins at arrow b, 40 min into the second IS session, and which lasts without break until the end of the session, it is not unreasonable to say that, the material that the subject was trying to access in almost two hours of study time (exactly 108 min) could easily have been accessed in less than five minutes by reading the text from which the LT tape recording was made. That particular difference between listening and reading is an astounding order of magnitude. Another way of expressing it is to say that a sighted student with the same interactive study purposes as those of Subject #26 in Fig. 20 could have accomplished all that Subject #26 did in less than 5% of the study time.

But then, there is another important point of difference to consider. Would a sighted student have had the same interactive study purposes? The answer is clearly no, for the sighted student would spend much more time searching the narrative, which is a practical option (and the only real successful one in most instances of confusion) while reading from a textbook. Thus the sighted student would have no real reason (especially during an IS session)

Figure Legend

Figure 21. Individual study session with an LT tape for Subject #26. Tape location is shown as a function of study time for the third IS session of Unit #12. The entire session is taken up with the interactive study strategy.

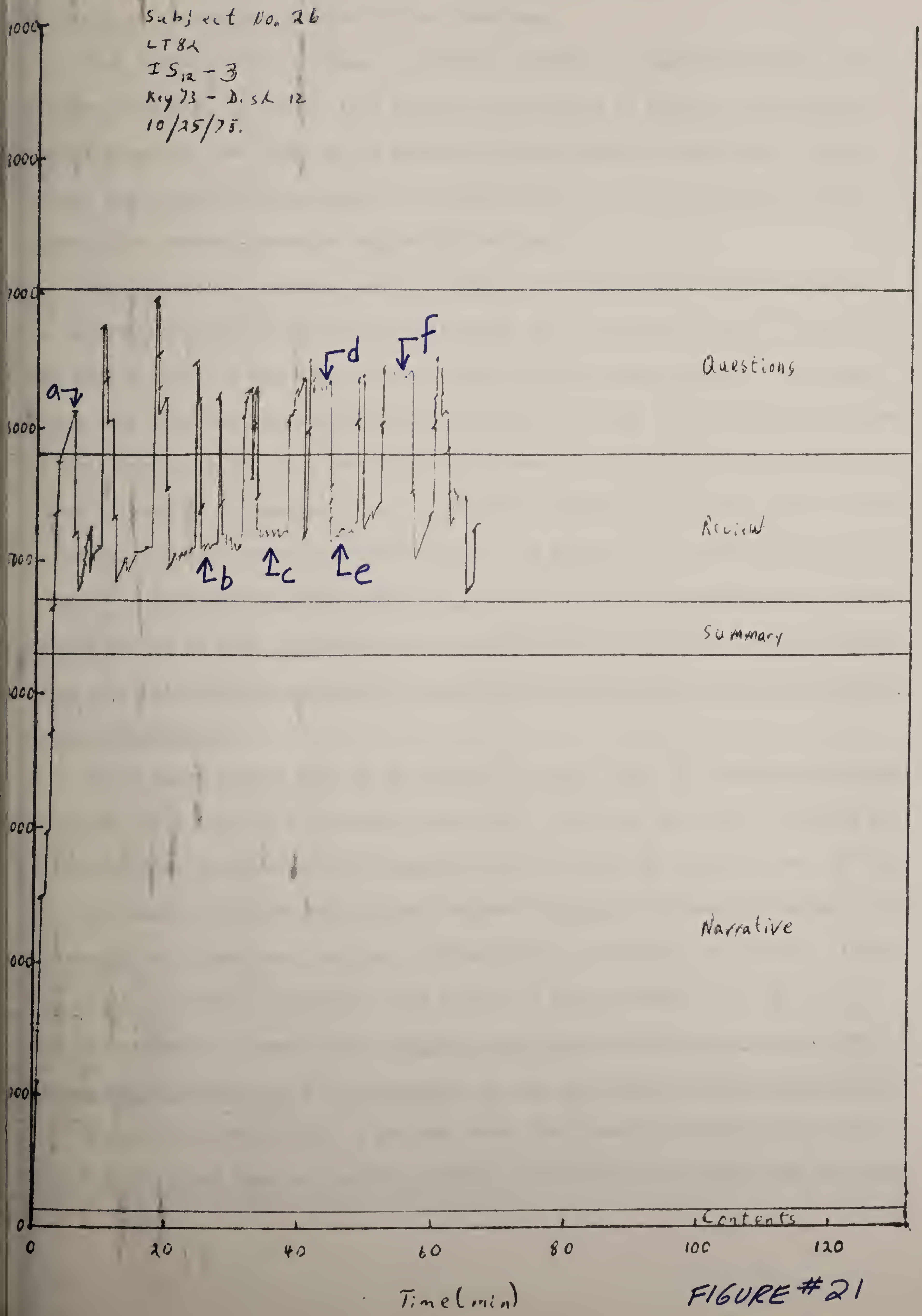
Subject No. 26
LT82
$IS_{12}-3$
Key 73 - Disk 12
10/25/75.
1000
3000
7000
5000
700
000
000
000
100
0
a
b
c
d
e
f
Questions
Review
Summary
Narrative
Contents
0
20
40
60
80
100
120
Time (min)

FIGURE #21

for going back and forth between question and review items in the hope of arriving at reasonable answers to the questions.

That Subject #26 continues to restrict himself to that interaction option is seen from Fig. 21, which is a record of the third IS session occurring in the afternoon of the same day on which the second session took place. This better than one-hour long session is clearly more of the same inefficient LT interaction between question and review sections.

Note especially how the session begins, remembering that Subject #26 is an experienced operator of the tape recorder (he is studying Unit #12 late in the fourth month of Exp III). It is clear that the study purpose of the numerous tape recorder operations preceding arrow a in Fig. 21 is solely to arrive at that tape location -- a particular question. In spite of the fact that it is well known to the subject that the question section is the very last section, it takes four minutes to find the section, and another two minutes to locate the question. Thus Subject #26 begins the third IS session by spending six minutes searching for an item of content that surely would have taken a sighted student less than six seconds to locate by turning the pages of the text from which LT Tape #12 was recorded.

It is worth noting that in 66 minutes of study time, 10 search-return cycles occurred for a rate of 0.15 cycles per minute, which is just about the same rate of interaction episodes as was computed for the second IS session shown in Fig. 20. And again, considering what the subject is doing in those 66 minutes -- i.e., listening to a question, finding a review item to which it is related, listening to it, and then returning to the same or a new question -- it is not at all unreasonable to assume that the same study purposes could be accomplished by a sighted student in 5 to 10 percent of the time taken by the aural learner.

There is another point to be made about the records of Subject #26 studying Unit #12, and that is that the subject is putting out a great deal of study

effort. Remember, that in studying Unit #12, Subject #26 emitted a total of 1860 responses on the tape recorder, which shows why the overall activity level seen in Fig. 18 is just as high for LT units as it is for AS units. Note that the subject almost never rests, the low rate of search-return cycles hardly being due to lengthy stop times. Also, as another indication of the premise that the subject is trying hard to understand the material, note the several instances of re-listening over and over again to question and review items (as at arrows b, c, d, e and f in fig. 21).

The three IS sessions we have examined so far have all been in preparation for the fourth, which is depicted in Fig. 22. That is, it was in this fourth session of almost three hours that Subject #26 tape recorded his answers to the questions at the end of the Unit #12 tape. And this question-answering session raises some questions concerning what would have happened to the LT study performance (and, of course, the exam scores from LT units) if the numbered questions, the numbered review items correlated with them, and especially the procedural requirement to respond to them, had not been included as part of the LT study conditions of Exp III. Certainly our LT data for both subjects would have been quite different, and particularly so for Subject #26. The amount of LT interaction would have undoubtedly been much less. It is quite reasonable to speculate that the enormous output depicted in Fig. 22 would never have even occurred. And yet, as we have pointed out, the question-review sections of the LT tapes in Exp III are not characteristic of most LT tapes which blind students study from. Those sections are derived from (and thus are a property of) the adaptation structure.

Skipping ahead to Fig. 23 for a moment, we see a record of Subject #26 during his only RS session. The exclusively passive study strategy shown in this figure, which is entirely typical of both subjects' LT study during RS sessions, supports the contention that the AS properties included in the LT

Figure Legend

Figure 22. Individual study session with an LT tape for Subject #26. Tape location is shown as a function of study time for the fourth IS session of Unit #12. The questions at the end of the LT tape are being answered during this study session.

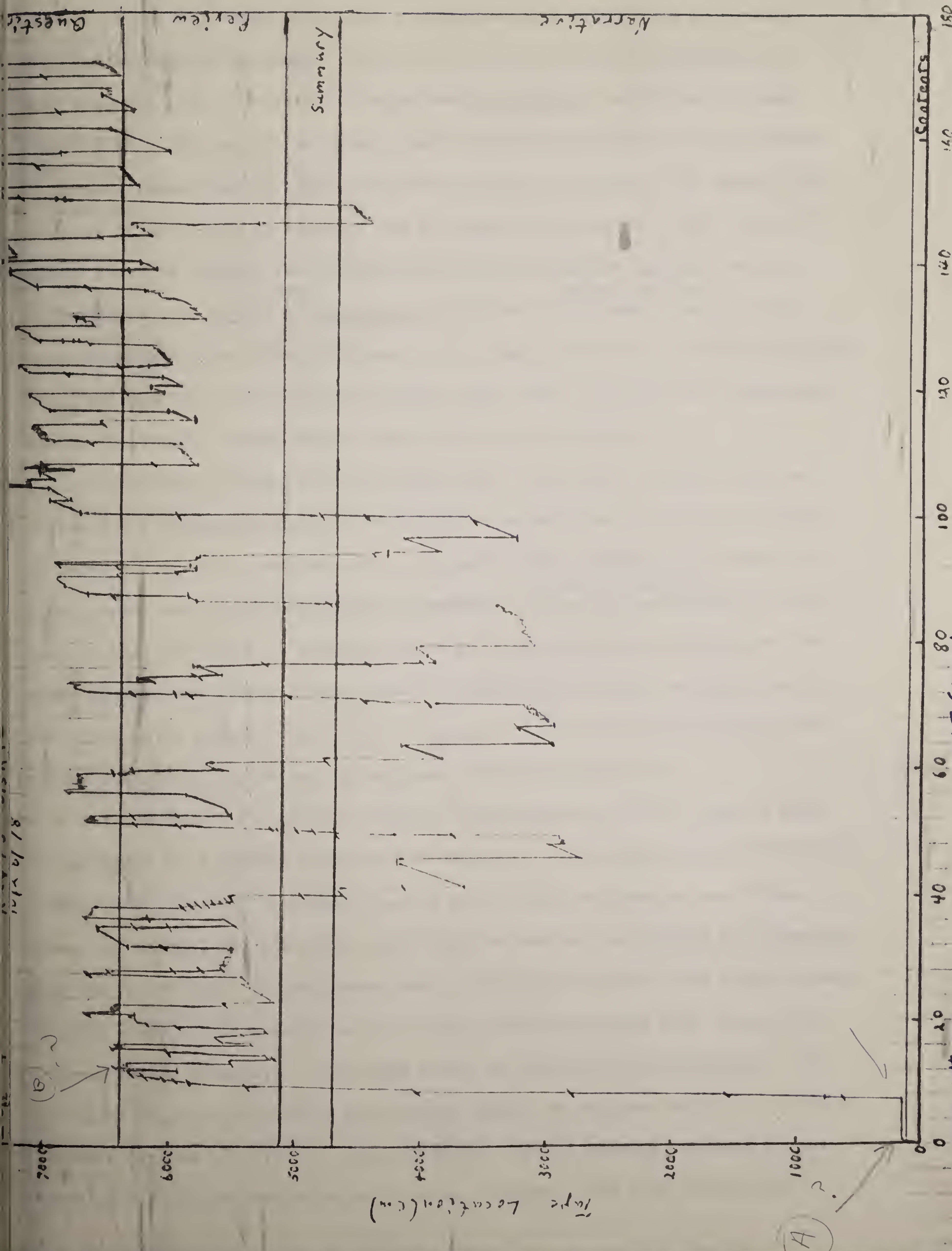
Questi
Review
Summary
Narrative
Sentences
Tape Location (cm)
7000
6000
5000
4000
3000
2000
1000
0
0
20
40
60
80
100
120
140
160
180
TIME (MIN)
B ?
A ?

FIGURE # 22

version of Exp III resulted in more interaction than would have occurred in the typical case of LT study. In spite of the fact that RS sessions occur just before a test, there is no longer any *requirement* to respond to questions, and so LT interaction drops almost to the zero point for both subjects. As we have seen, however, both subjects continue to interact with review and question items during RS sessions for the study of AS tapes. Why? The only answer could be because the questions and review items are helpful during a review for a test *and* it is more *practical* to interact with them when they are part of the adaptation structure. With AS tapes, it is always feasible to obtain reasonably rapid explication of review and question items which are still not understood. Again, "reasonably rapid" means seconds instead of minutes.

In retrospect, however, we are very glad, for several reasons, that we included the unusually numerous review and question items at the end of each LT tape, and also the requirement to respond to the questions. In doing so, a very important purpose which was served was to provide examples of LT interaction such as are seen in Figs. 20 -- 22 -- examples of an LT study performance which show the aural learner is "really trying hard" to understand the tape recorded content. The other major purpose which was served was, of course, to hold constant the verbal content of the AS and LT versions of the ecology course.

For the reader who has the time and inclination to do so, there is much to be gained by a careful study of the details of the lengthy fourth IS session shown in Fig. 22. By imagining you are at the tape recorder as you follow along the record, you can often infer what the subject was trying to accomplish. And, as you do that, if you glance down at the time line for each study episode, you will come to appreciate what an arduous and frustrating task it was for Subject #26 to study with an LT tape which was difficult to understand. You will also begin to appreciate the unusual amount of patience which is required for this kind of LT effort at understanding. So try placing yourself in the shoes of a blind student studying from an LT tape, using your imagination.

For example, in the first 15 minutes of the study session shown in Fig. 22, the subject moves forward just past the contents and then stops at arrow *a* for almost seven minutes. That is, of course, an example of *study break time* and is deleted from *total study time* when computing the statistic called *active study time*. The subject then uses the forward mode to go to the first question at arrow *b*, making 12 interruptions along the way to check on his tape location. In moving from arrow *a* to arrow *b* on the tape, the subject used up over six minutes of study time. Again, with a book, a few seconds is all that would have been required to achieve the study goal of finding the first question in a section of questions at the end of a chapter. Thus *checking the tape* (with short play durations) is a frequent event in LT study and takes up a lot of study time.

There are a few other properties of Fig. 22 which we will describe which we feel are important to point out. To begin with, *most of this three-hour study session is spent as search time, not learning time*, and it is the same kind of relatively inefficient searching that we have seen in the previous two figures. From the positive slopes of both the peaks and depressions in the search cycles, it is clear that Subject #26 is interacting with successive questions and also locating corresponding review items. In this record, the search cycles include stop time for tape recording responses to the questions, but those stops are negligible for they are generally under 30 sec. For the most part, they do not even appear on the record of Fig. 22.

It is important to note that even after almost five hours of prior study (in the first three IS sessions), Subject #26 is still not able to respond to most of the questions. In general, upon listening to a question, the subject is not sure of the answer to tape record. This is further evidence that Unit #12 was especially difficult for this subject, which makes the passive study strategy used at the start of study all the more inappropriate.

With the exception of five excursions into the narrative, the subject still limits his attempts at explication to searching the review section. Excluding those five cases of searching the narrative, there are approximately 16 distinct search cycles which extend into the review section. These occur in approximately 82 minutes of study time, for a rate of about 0.2 cycles per minute, or on the average, more than five minutes per cycle. It is clear from an inspection of these 16 search cycles that the greater portion of those 82 minutes is spent as search time. Again, the reader is urged to consider the case of a sighted student attempting to accomplish a study goal corresponding to that shown in Fig. 22, but with a textbook instead of a tape recorder. Once you subtract out the search time (or rather, reduce it to a few seconds of visual scanning per search cycle as opposed to minutes per aural search cycle), most of the three-hour session shown here would have been unnecessary, or else could have been spent in productive learning activities rather than the frustrating efforts of which Fig. 22 is evidence.

In Fig. 22 we see again, from an examination of the five cases of searching the narrative, why that activity is rare during the study of LT tapes. Note that all five search cycles take much more time than the 16 cycles where searching the review section is occurring. About 63 minutes of study time was used up in the five narrative searches, for a rate of about 0.08 cycles per minute. On the average, that is more than 12 minutes per narrative search cycle, as compared to a little more than five minutes per review section search. It is, therefore, no wonder that blind students give up trying to interact with the narrative of LT tapes, keeping in mind that less than 5% of those entering high school ever reach the point of graduation. Rather, it is a wonder when they do not, as in the case of the very small minority of visually impaired students who make it through high school.

It may also be derived from Fig. 22 that search time with LT tapes is an increasing function of the tape distance between the terminal locations of the

search. That function is complicated by many kinds of factors (e.g., how many times a tape has been listened to, how well it has been remembered, how well it has been understood, etc.), but in many cases, it is undoubtedly not linear, but positively accelerated. In any case, after enough experience with LT tapes, all blind students will learn the unhappy reality of that function: *if you want to re-listen to something you heard before, the further removed it is from your present location, the longer it will take you to find it, and the longer it will take you to return to where you started from.* The knowledge of those relationships is probably why LT interaction, when it does occur, is mostly restricted to going back and forth between adjacent question and review sections. Searching the narrative is a very unrewarding activity from the standpoint of search time. Searching the review section is very unrewarding from the standpoint of explication. The compromise performance which results can be summed up in two words: *study inefficiency*.

Having responded to all of the questions on the LT tape for Unit #12, Subject #26 returned to the laboratory one week later to take the unit evaluation (a test of 100 questions). Before doing so, however, there was one more study session which is hsown in Fig. 23. This RS session is much like the first IS session shown in Fig. 19 -- the extreme case of the passive study strategy -- and is typical of the RS sessions for both subjects when they prepared for exams using LT tapes.

It is interesting that there is no interaction with the review items that are listened to, and the subject doesn't even finish the review section or re-listen to any of the questions. In contrast, when reviewing with AS tapes, the question and review items of each LS were consistently used by both subjects. That is because it is practical to use them *in conjunction with* the narrative parts of the LS. No matter where the subject is located on an AS tape, access to corresponding narrative is always just seconds away.

So the relationship which we have seen to be a major disadvantage of

Figure Legend

Figure 23. Individual study session with an LT tape for Subject #26. Tape location is shown as a function of study time for the first (and only) RS session of Unit #12. The performance is a return to the passive study strategy.

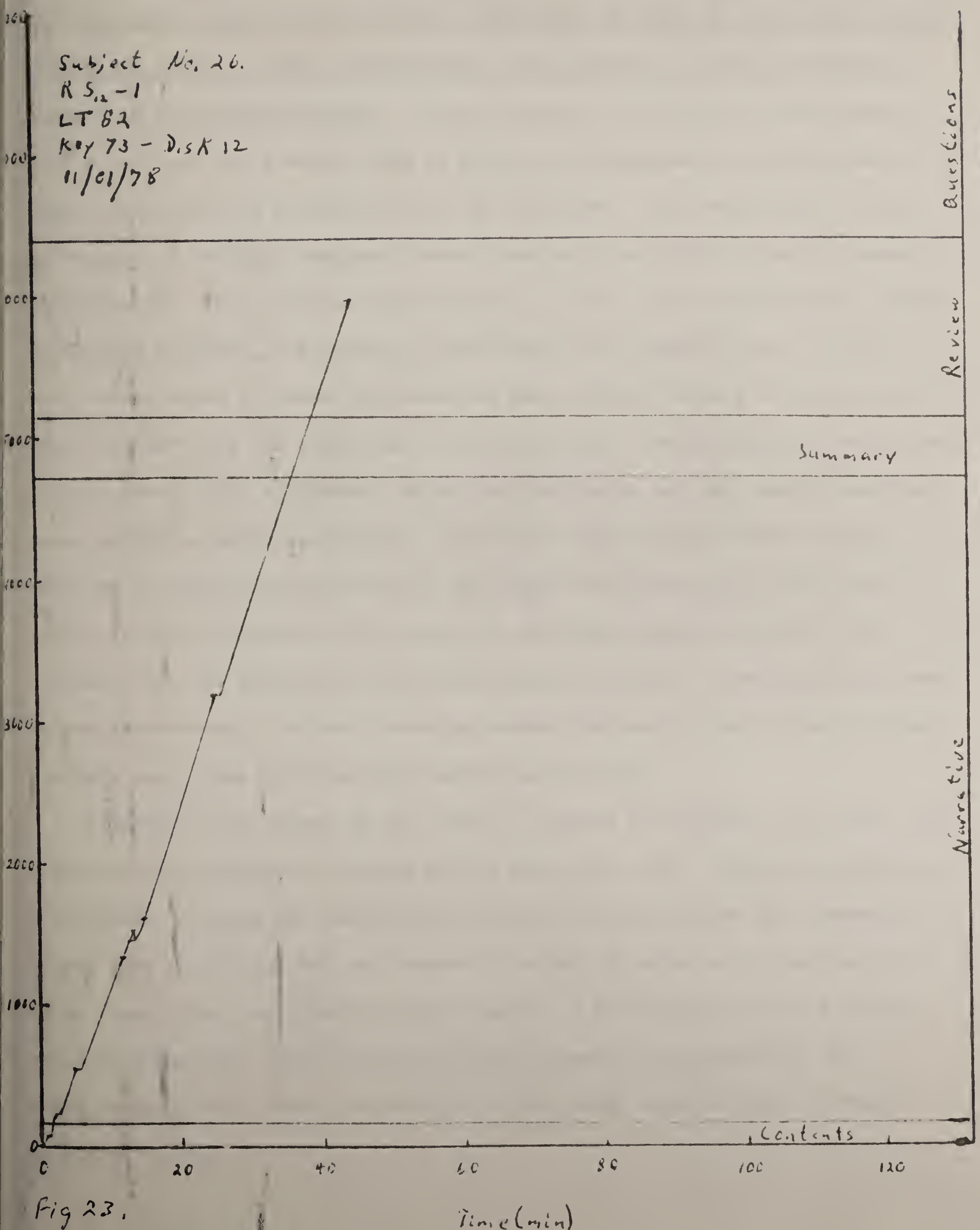
Subject No. 26.
R S12 -1
LT 82
Key 73 - Disk 12
11/01/78
Questions
Review
Summary
Narrative
Contents
Tape Location (cm)
000
000
000
3000
2000
1000
0
0
20
40
60
80
100
120
Time(min)

Fig 23.

LT tapes -- that search time is an increasing function of the tape distance between starting point and target point -- does not apply to AS tapes (not including the time taken to rewind or forward the tape recorder). That is, with AS tapes, search time is almost independent of where in the tape the search starts and where it ends, excluding the extra seconds it takes to rewind or forward to more distant points. In that respect, AS tapes are functionally like a textbook where search time is also quite independent of the number of pages separating the terminal points of the search. One reason that is true is because of the high frequency index tones which separate listening segments and LS parts. They serve as anchor points. At any given time during a rewind or forward response, the subject always knows his location (i.e., at the very least, which LS number and which LS part) without having to make several spot "checks" with the play mode to discover that. Overshooting and undershooting are practically eliminated, except as they occur for very small tape distances within a particular LS part. Thus the subject always knows not only where he is, but also how to get to any target location by the most direct route, selecting Channel A for expository and interrogatory material, and Channel B for the commentary and review parts of the LS. Counting index tones allows for zeroing in on any listening segment and any LS part without making a single spot check with the play mode along the way.

Figure 24 is a record of the first IS session for Subject #25 on Unit #12 (the same unit studied by Subject #26 in Figs. 19 -- 23). This time, however, the subject is using the adaptation structure. Tape location for Channel A (lower portion of Fig. 24) and Channel B (above) is shown as a function of study time. Tape locations for both Channels A and B are to be read off the abscissa time scale which applies to either Channel A or Channel B, but never both at once. Thus the duration of the study session shown in Fig. 24 is almost 47 min.

Figure Legend

Figure 24. Individual study session with an AS tape for Subject #25. Tape location is hown as a function of study time for the first IS session of Unit #12. The solid bands show index tones which separate listening segments. The other bands show the broken index tone which separate LS parts. The lower half of the figure is for Channel A and the upper half shows Channel B data. LS #1 (the tape contents) and the four parts of LS #2 (as designated in the body of the figure) are studied in this session.

Key 27

11/10/18.
Subject #25

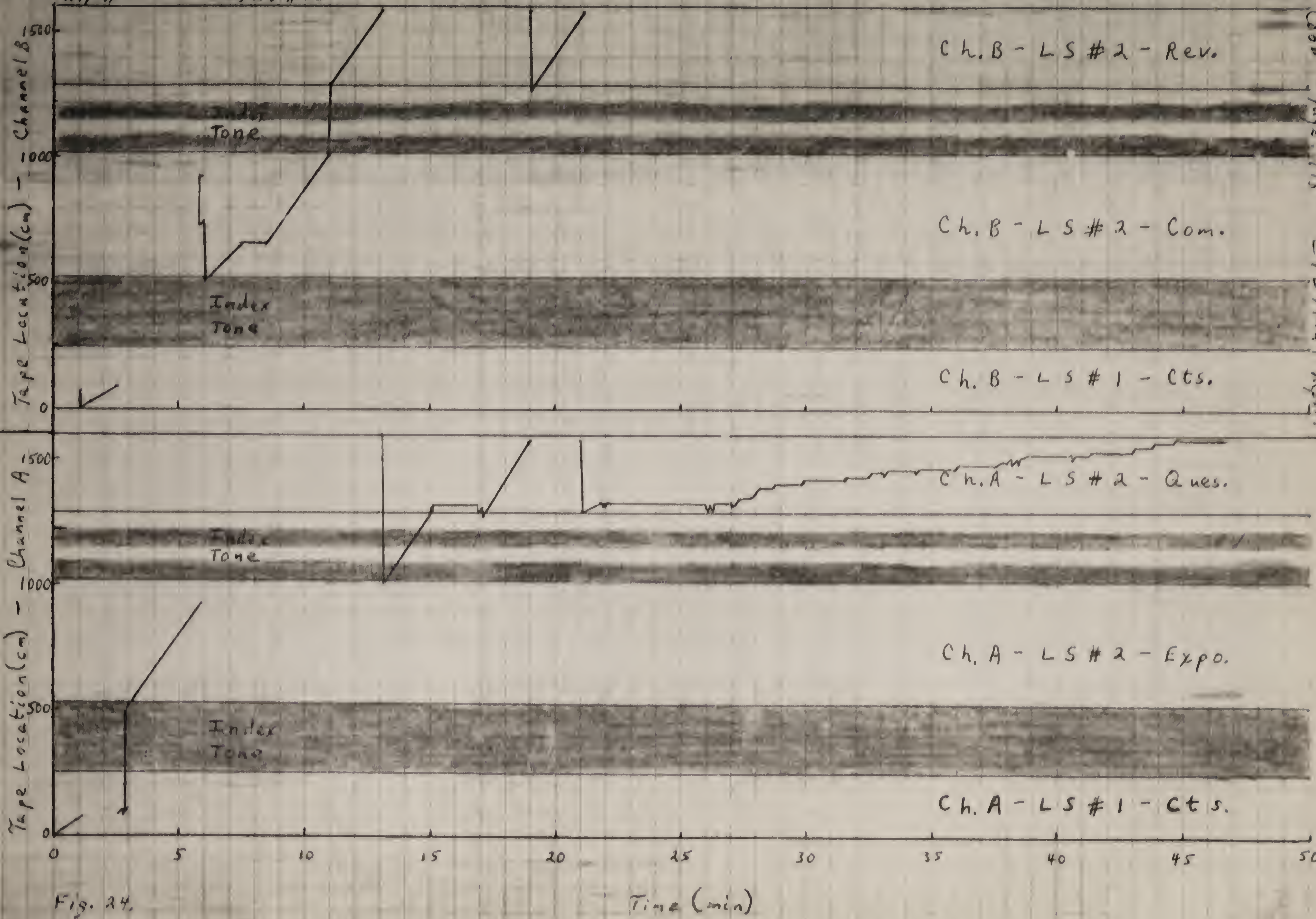

Fig. 24.

Figure 24 should be contrasted with the previous individual records for the study of the LT version of Unit #12. There is almost no wasted effort here because of moving too far or too short of target material (i.e., overshooting or undershooting). With few exceptions, each of the subject's responses accomplishes the study purpose for which it is intended. The subject doesn't need to make 20 to 50 operations of the tape recorder to get where he wants to get. Search time is at a minimum, approaching the case of a sighted student reading from a text.

Thus Fig. 24 shows the subject locating material relatively efficiently, within a few seconds in all cases, as contrasted to several minutes for the LT version of Unit #12. The subject always knows where he is and where to go (or, better yet, how to go) in order to find the next material to be studied. There are three major reasons why that is so -- reasons which differentiate the adaptation structure from the literal transcription (i.e., printed-text) structure:

1)The subject has frequent and meaningful reference points which differentiate one LS from another (the continuous index tones, shown as two solid bands in Fig. 24), and which differentiate the four LS parts from each other (the two tape tracks called Channels A and B, and the intermittent index tones, shown as two broken bands in Fig. 24).

2)The identification of LS content occurs in several places and in several ways. At the start of each LS, the segment is identified appropriate to its number, title and main thrust of its content (i.e., the first thing which is heard at the beginning of every LS is, "This is LS number ______; it is about . . . such and such"). And at the beginning of each (hour-long) tape, two kinds of LS contents information are provided. On Channel A, the title of each LS is followed by a sentance describing the major point(s) of content; and on Channel B, the major wordsand phrases (especially when they are introduced

for the first time) are associated with each LS in which they occur. And at the end of each hour-long tape, there is a summary segment where half of the LS's are summarized on each of the two channels. The summaries are condensations of major points made in the listening segments.

Thus the aural learner using an AS tape can access contents information at the start of an LS, or at either end of the tape, whichever he happens to be closest to. And if more detailed contents information is needed, the part containing review items on Channel B of each LS provides a very complete picture of what is in the narrative parts of the LS.

3) *The length of LS parts is always relatively short*, so in searching for something, there is never a great deal of tape through which the subject has to hunt (as in the case of the LT structure). Thus, after one or two exposures to the content of the four parts of a given LS, it is easy to remember *what is said* or talked about and *where it is said*. That memory is aided greately by preserving, where possible, the *sequence of information* in each of the LS parts during the writing of the AS materials. Thus, if several points are made in the exposition, those points are referred to in the commentary *in the same order* in which they were introduced in the LS; and the numbered review and question items preserve the order also, in addition to indicating which tape channel (A or B, or both) contains the material referenced.

Therefore, as long as the aural learner is working within an LS, he never has long tape distances to move, either in the forward or rewind modes. Because the review and question parts of an LS are adjacent to the two narrative parts, study interaction between all four LS parts requires, *at the most*, F or R response durations of a second or two. Often all that is required is a flip of the channel selector switch, when interaction is occurring between the LS narrative parts, or between the question and review items.

In the relatively rare case where the subject wishes to interact between

listening segments, tape distances are a little greater (but still no where near what they are with LT tapes), but that has an almost negligible effect upon search time, in contrast to the situation for LT interaction where search time is an increasing positively accelerated function of the tape distance between the terminal points of a search. To understand why AS search time is so independent of search distance, consider the following hypothetical case of interaction between LS's (which is typical for both subjects in Exp III).

A student is studying the commentary of LS #5 of an AS tape. A technical term is heard which was defined earlier in the tape. The student is not sure of the meaning of the term, nor even in which LS the formal definition occurred. The student decides that maybe LS #2 is the place to search for some explication of the term. His procedure is as follows:

	Time
1) Flip track selection switch to Channel A.	1 sec
2) Rewind and count the occurrence of four continuous index tones and three interrupted tones.	20 sec
3) Play at the occurrence of the fourth continuous index tone, hearing "This is LS #2; it is about . . . (such and such)"	5 sec
4) Forward (because LS #2 is immediately rejected as the relevant LS) and count the occurrence of one interrupted and one continuous index tone.	7 sec
5) Play at the occurrence of the continuous index tone, hearing "This is LS #3; it is about . . . (such and such)"	5 sec
6) Forward (because the student recognizes that the definition occurs near the end of the four-minute exposition)	3 sec
7) Play with the ensuing recognition of location in the narrative of the searched-for definition.	2 sec
TOTAL SEARCH TIME	43 sec

If the student in the above example had been using an LT tape, the search of the narrative would typically have required five to ten minutes, as we have seen. Earlier, on page two of the introduction to this report, we

discussed the *reason* for this kind of study performance difference (i.e., seconds vs minutes of search time for AS vs LT tapes respectively) in terms of a difference in the *amount of control* the listener has over the presentation to be studied. In the case of LT tapes, *the tape structure controls the student* in the sense of limiting the student's interaction options. For example, if the structure is such that searching the narrative takes excessive amounts of time, even though the student is "free" to search the narrative with an LT tape, that option is, for all practical purposes, not available to choose from because the student can't control the presentation effectively once it has been chosen.

In contrast, as can be seen from the example provided in Fig. 24, the adaptation structure contains several sign-posts, as it were, to compensate for those available to sighted students, but which are lost in the literal transcription process from print to tape. And Subject #25 uses those sign-posts to direct his study activities once they have been decided upon. There is really no restriction here on what interaction option to choose, for they are all pretty much equivalent in terms of the search time required to execute them. The subject can move *anywhere* within an LS or between LS's by the most direct route, with a minimum of excess responding. In other words, in the case of AS tapes, rather than the tape structure controlling the student, *the student has control over the aural presentation structure*.

From our analysis of the study performances of the two subjects in Exp III, we may conclude the following:

1)With AS tapes, the interactive study strategy was always used for both *initial study* (IS) sessions and for *review study* (RS) sessions.

2)The interactive AS performances were very similar for both subjects -- in terms of both absolute and relative measures -- in spite of the fact that *the content of the AS tapes was totally different for each subject*.

3)Thus content does not appear to be an important variable controlling which study strategy is employed, provided the content is sufficiently challenging that the interactive strategy will serve to decrease confusion and result in explication. In other words, to the extent that the interactive strategy was *not* used during AS study, it is not unreasonable to assume that the content was pretty well understood with the passive stategy.

4)With LT tapes, one subject used the passive strategy consistently throughout. During IS sessions, the other subject alternated between use of the passive and interactive strategies (e.g., see Figs. 19 and 20). During RS sessions, however, both subjects used the passive strategy almost exclusively.

This subject difference in studying LT tapes is not explained by any of our findings. It is clear that Subject #26 was a lot more persistent in using the interactive strategy with LT tapes. It is worth noting that he began the study of the ecology course with AS tapes, which may have established an interactive tendency which persisted into the next block of LT tapes. An experiment would be needed to check that possibility out.

5)For both subjects, the study strategy was *more* passive in the second block of LT units than it was in the first block of LT units. A similar trend was *not* noted for the study of AS tapes.

6)When the interactive strategy is applied to the study of LT tapes, the resulting performance is very different from AS interaction in many ways -- ways which explain why that strategy is not applied equally to the two tape presentation structures. The simplest way to describe the difference is in terms of study efficiency. LT interaction is, in a word, *inefficient*! With AS tapes, search-return interaction cycles are accomplished quickly -- usually in a few *seconds* -- especially after some practice at using the adaptation structure. Searching the narrative occurs quite frequently, and the narrative search-return cycles do not take much more time to accomplish than searching the non-narrative sections.

In contrast, LT interaction involved a much lower rate of searches because search-return cycles take so much longer than is the case with AS tapes. Searching the narrative seldom occurred. When it did, search-return cycles typically took *several minutes*. The data that we have examined indicate that search time with LT tapes is a positively accelerated increasing function of tape distance between the terminal points of the search. That function readily explains the infrequent occurrence of searching the narrative. In contrast, with AS tapes, search time is relatively independent of the distance separating the start and end points of the search, approximating much more closely the function which would hold for visual searching through a text book.

Thus our analysis leads very strongly to the conclusion that certain educational presentations to be studied by tape recorder should be altered (or adapted) in ways that conform to the particular needs of a listener with a tape recorder. The specific alterations we have developed and tested in Exps I and III are just a beginning, but it is clear that our adaptation structure makes the aural study effort a great deal more efficient, and consequently more enjoyable (as reported by our subjects themselves) and, as will be shown below, leads to better comprehension and much better retention.

Thus it is not surprising that all 16 subjects represented in Table 1 reported that their experiences using AS tapes had convinced them that our alterations were a big improvement over the LT presentation structure. Many of our subjects wrote lengthy statements (which have been included in previous reports to the State Education Department) describing why they felt that AS tapes offered advantages. Such statements -- standing alone -- are questionable. However, in conjunction with the objective data presented here which differentiate the AS study performance from the LT study performance, these statements carry a great deal more weight.

Data relevant to tests following the study of AS and LT tapes. By now, the reader may be wondering which kind of tape presentation structure is "better"; that is, better in the usual (and crucial) sense of test performance. If it is true that AS tapes allow for more efficient study, then wouldn't one predict higher test scores on unit examinations following the study of AS tapes? Indeed, one would, and in view of the very substantial differences in study performance generated by the two tape structures in Exp III, one might well expect that examination performances following study with AS and LT tapes would also be substantially different. In the present case, however, that expectation must be tempered by a consideration of several factors operating in Exp III, all of which would function to reduce the differences in test performances following study with the two types of tape structure:

1) In the first place, it should be noted that Exp III was not designed to test an hypothesis about differences in test performance as a function of the tape structure used during study; it was, instead, addressed to the question of how study performance differs as a function of the tape structure used during study. And it is simply not true that an answer to the latter kind of question will provide unequivocal information about the former, not with the design of Exp III, at least. That design would not be so much of a problem in the interpretation of test scores were it not for the fact that there is an interdependence of content across the twelve units of the ecology course that the two subjects learned. Thus, in Exp. III, the data on test performance are thoroughly confounded by the data on study performance.

There are two cases of interaction to consider, both of which would function to produce a convergence of mean test scores which measure the effectiveness of the two tape structures. Since the content of the twelve units is, to some extent, sequentially dependent, a subject's preparation for learning Unit #12,

for example, is dependent upon how well Units 1 -- 11 have been understood. Assuming, for the moment, that AS tapes yield better comprehenson (an assumption supported not only by the study performance data presented thus far, but also by the test-score results we will discuss), then, because of the sequential dependency of content, poor comprehension resulting from the study of three successive units of LT tapes would serve to lower the test scores on the next three units studied with AS tapes; and conversely, the better preparation resulting from the study of an AS block of units would serve to raise the test scores on the next three units studied with LT tapes. Thus, if study with AS tapes does produce better comprehension than study with LT tapes, our test scores would not show the "true" difference in test performance, for the design of Exp III would serve to reduce the expected difference in the two sets of test scores following study with each type of presentation structure, raising the LT scores and lowering the AS scores.

2)Our study performance data have shown that the probability of using an interactive study strategy is very high with AS tapes, and much lower with LT tapes. It is undoubtedly true that if study with AS tapes leads to better comprehension than study with LT tapes, a very important reason why that would be so would be because the interactive strategy is used more with AS tapes than with LT tapes. Given that premise, then any factors which were part of the conditions of Exp III which would serve to increase the amount of LT interaction(above what would ordinarily take place)would also serve to increase test scores after LT study (above what would ordinarily take place). Did such factors exist?

They certainly did, and they undoubtedly increased the amount of LT interaction well beyond what would have occurred had their influence not been present. There were many instances when the subjects did use the interactive strategy while studying with LT tapes. When it occurred, it was usually during IS sessions when the subjects were trying to satisfy the procedural

requirement of responding to the numerous questions at the very end of the LT tape (for an example, see Fig. 22).

Those questions, the requirement to respond to each one of them, and their high correlation with the numbered items in the adjacent review section are three factors which would all operate to increase the use of the interactive study strategy during the study of LT tapes well beyond what would otherwise be seen to occur. There is another factor in the design of Exp III which might have inflated the amount of LT interaction, and that is the influence of beginning the study of the ecology course with a block of AS tapes. That was the case for Subject #26, and it was he who used the interactive strategy with LT tapes much more than the other subject, who began the ecology course with a block of LT tapes.

Thus, assuming that the interactive strategy leads to better comprehension than the passive, these four factors taken together constitute another feature of Exp III which could serve to decrease the differece between mean test scores associated with the study of the two tape presentation structures.

3)Several aspects of the conditions of Exp III, other than what we have mentioned so far, would serve to heighten attention during aural study over that which would ordinarily take place. For example, the fact that the subjects knew that their study behavior was being monitored; or, the fact that examinations were always administered immediately after an RS session. Assuming that the AS tapes produce higher attention levels during study than is the case with LT tapes (an assumption which is supported strongly by our data on study activity performance, Fig. 14 being an especially striking example), it would be expected that attention-getters which are independent of tape presentation structure such as knowledge of being monitored or proximity to an examination would serve to operate more on behavior during the study of LT tapes (where attention is low) than during the study of AS tapes (where attention is

higher), again reducing the difference between mean test scores for the two tape structures beyond what would otherwise be seen.

4)The difficulty levels of the content for the twelve eclolgy units was not constant, nor were changes in difficulty consistently related to the sequence in which the tape structure was alternated. This uncontrolled variable, then, served as yet another source of interaction, greatly increasing the variability of test scores. The counter-balanced design of Exper. III would tend to control for such confounding effects if, say, eight or more subjects had been used in the experiment. In the present case, however, with only two subjects providing data, statistical tests of the differences observed between mean test scores for the two tape structures would be, at best, equivocal. Certainly it is true that any real differences in comprehension would be substantially masked within the high variation produced by the inter-unit variability in difficulty level.

Thus, inherent in the conditions of Exp III are four areas which would tend to obscure, in a significant way, any real differences in comprehension produced by differences in tape structure. Again, Exp. III was not designed to answer questions about comprehension for the two kinds of tapes. Therefore, any differences in comprehension favoring study with AS tapes must be considered as advantages which were manifested in spite of these four sources of confounding which we have just discussed. Are there any?

Yes, all mean scores measuring comprehension were higher after study with AS tapes than with LT tapes. As might be expected from the discussion above, the largest significant differences were seen for a measure of retention, using the items missed by both subjects in Exp. III on the final examination covering all twelve units, administered four months after the start of the course. Figure 25 shows a comparison of the percent of fill-in questions on the final examination which were answered incorrectly. The data are means for the two

Figure Legend

Figure 25. Mean percent of fill-in questions on the final examination which were answered incorrectly. AS and LT blocks are shown separately as well as combined. All differences between means are statistically significant at low probability levels (as ascertained by inspection). The data are averaged for Subjects 25 and 26.

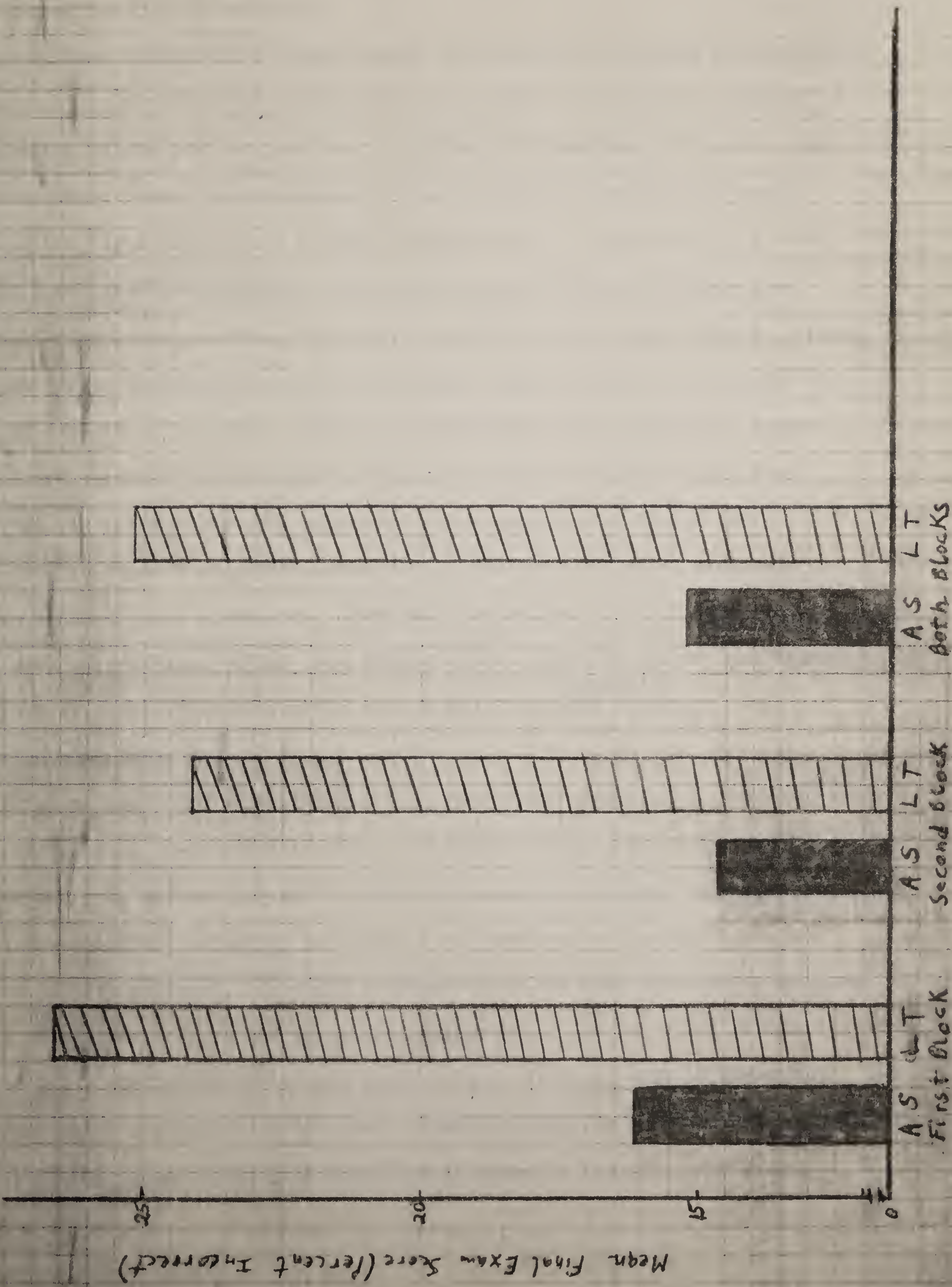
Mean Final Exam Score (Percent Incorrect)
25
20
15
0
A S
L T
First Block
A S
L T
Second Block
A S
L T
Both Blocks

Fig. 25

subjects. The differences shown in Fig. 25 indicate a much better retention for the content studied with AS tapes (which, it is worth reiterating, was not the same for the two subjects).

As we have indicated, the mean scores for the tests following the study of each of the 12 units were also higher for the study with AS tapes. Each of those tests, called unit evaluations, contained 100 questions. Sixty of them were true/false items, testing memory by the recognition method (and where guessing the right answer is a highly probable event). The other forty items were fill-in-the-blank questions, requiring the more difficult memory task of recall (and where guessing the correct answer is a much less probable event). Mean unit score differences for the true/false items favored the AS tapes, but were not significant ($p > .05$). However, significantly (by inspection) higher scores were obtained for AS tapes on the unit evaluation fill-in questions.

Thus, in spite of factors inherent in the experimental design which would tend to obscure any differences in comprehension following study of the two kinds of tape structures, clear and statistically significant test score data were obtained which show that AS tapes result in better understanding when that is measured shortly after the study of the tape, and/ especially in a test of retention much later on.

Prior to that test of retention (i.e., the final examination), both subjects were permitted to review all 12 units. Although this procedure further confounded the data on test scores for the final exam, our primary interest in Exp. III was identifying study performance differences for the two tapes, as we have already stressed. As might be expected on the data from the RS sessions during unit study, the review sessions in preparation for the final examination showed a consistent use of the passive study strategy with LT tapes and the interactive strategy with AS tapes. That was true for both subjects. They also spent more time studying AS tapes, as is shown in Fig. 26. The left

Figure Legend

Figure 26. Total and active study time (left ordinate) and relative study break time (right ordinate) for study sessions in review for the final examination. Blocks 1 and 3 are for the study of LT tapes and Blocks 2 and 4 are for AS tapes. Data are from Subject #25.

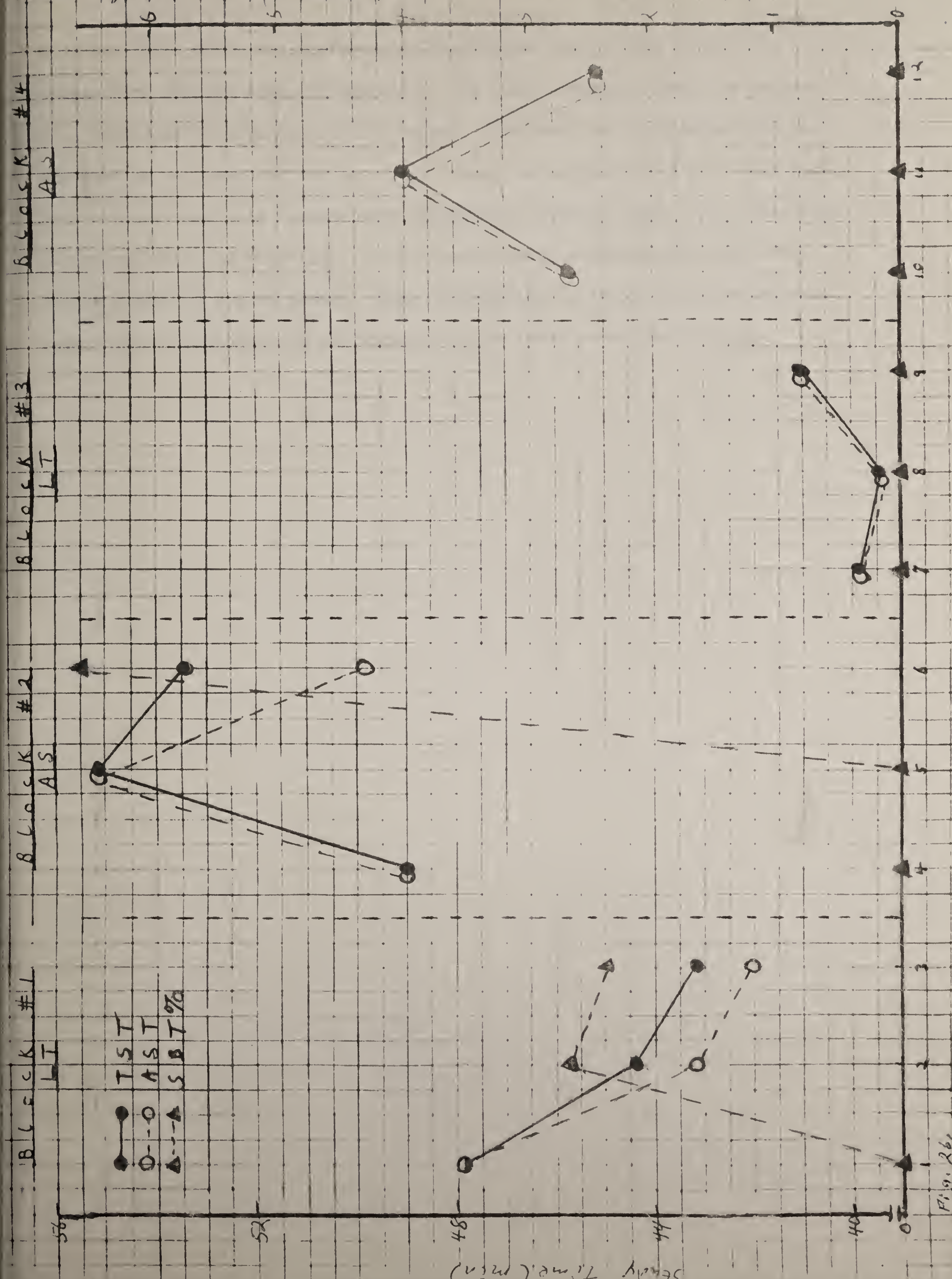
Block #1
LT
Block #2
AS
Block #3
LT
Block #4
AS
TST
AST
SBT%
Study Time (min)
Study Break Time (Min)
Units
56
52
48
44
40
0
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10
11
12

Fig. 26.

ordinate shows total and active study time during each review session in preparation for the final examination. The right ordinate shows the percent of study break time during those sessions. The data are for Subject #25 and are similar to those for Subject #26. Thus, in reviewing for the final exam, both subjects not only studied more efficiently with AS tapes (i.e., they both interacted with the material), but they also spent significantly more time in the review of the AS tapes. These differences in review study performance undoubtedly influenced the differences in the examination performance.

V CONCLUDING REMARKS

The scientific potential of SOS research. The development of our aural learning laboratory and the capacity to use it for carrying on SOS (for the "study-of study") research has not proceeded smoothly. Since December of 1976, when our first pieces of laboratory equipment were tested out, there have been several interruptions in our work, one of which lasted for fourteen months. And as this report is being written, we are in the fourth month of yet another period without any funding at all, waiting to see if a pending federal grant proposal will be awarded. Given the current political climate, the prospects are not at all encouraging.

And yet, there is still one area about which we can be strongly optimistic, and that is the potential of the research tool which has been developed and tested out on the Learning Through Listening project. The data that we have presented in this report are but a very small sample of what we collected during the thousands of hours of study sessions which occurred over a two-year period. And the analysis of the data which we have presented here is but a beginning next to the information which still remains to be obtained from more sophisticated treatments of the study performances of Subjects 25 and 26. But the data, and the analysis of them, are enough. They are much more than enough.

Enough for what? Enough to demonstrate the scientific potential of a new research tool. Enough to show that the experimental analysis of aural study activities can lead to knowledge which has practical (as well as theoretical) significance for education. Enough to more than justify what has been expended and experienced in terms of time, money, hard work, dissapointment, and yes, even despair, all of which have been a part of our collective effort. So in ending this report, we will now make a few points about the implications of that effort -- implications which have been realized, as well as some which are just slightly beyond our reach.

The exposition and definition of an educational problem. Three years ago, we published an article describing our work on the LTL project up to that point (Cobb, 1978). The title of the article was, A Step in the Direction of a Science of Education: The Measurement of Independent Aural Study Activities Generated under PSI Contingencies. In addition to its being rather imposing, the title was, at the time the article was written, certainly a bit presumptutous, especially in view of the fact that we had only just begun to collect study activity data, and had subjected none of them to analysis. But the title, and the introduction which followed it, reflected our faith in the benefits which would result from an application of the scientific method to the analysis of aural study. Thus we began that article by talking about the advantages of careful quantitative measurement -- advantages which we could only describe as part of the history of science. The introduction ended with reference to attempts to measure what's happening in the process of educating students, including our own attempts. We said:

> "Such measuring activities represent a step toward a science of education, and some benefits can be described in terms of the increased potential for corrective action." And further, ". . .teachers, and the presentations they provide, are not exempt from the effects of recording measurements: once the data are available, corrective action is impelling."(ital. added).

Why corrective action? Because we were confident (from the history of science) that our procedure of measuring what blind people do while studying with tape recorders would expose, and allow us to begin defining, some of the problems they experience. From those who have had the patience to read our presentation of the results of Exp III, we will surely get agreement on that score. Blind students are by no means on an "equal" footing with sighted students with respect to the independent study of school assignments. If that fact has been appreciated by some in the field of the education of the blind, it is certainly not a universal recognition. And it is doubtful whether any but the aural learners themselves would not be surprised by the

magnitude of the problems encountered in study with a tape recorder.

So our new SOS research tool has accomplished the important purpose of identifying a serious problem with which blind students must contend. Now that ". . .the data (presented here) are available, corrective action is impelling", or at least, it should be. We are no longer in a position to publish statements to the effect that literal transcription tapes provide the blind student with an ". . .equal opportunity" -- equal to a sighted student studying from a textbook -- for we know that is not true. Really, we always knew that, but the data help us to admit it. It is now quite clear that the opportunity is very unequal.

A demonstration of a way to ameliorate the problem. Since we measured study performances not only with LT tapes, but also with an alternative presentation structure, we were able to demonstrate an important principle with our new SOS research tool. We will call it the principle of aural adaptation. We showed that by altering the tape presentation structure (with content held constant) so that it conformed to the needs of a listener with a tape recorder, we could make significant reductions in the difficulties encountered when studying with LT tapes.

At this point, we want to emphasize that the demonstration which was accomplished through SOS research, and which is an important demonstration, is not that the AS tapes which we used in Exp. III offered significant advantages for aural study. They did, of course, but the changes that we have tested out are but a scratch on the surface of what can be done to make tape recorder learning more efficient and more enjoyable. We have not even responded to the data in hand, and many more remain to be analyzed. In addition, our research has raised numerous questions which are entirely amenable to an experimental analysis with SOS research procedures, both existing and potential. Therefore, the aural adaptation structure which we have used to

date can only be described as *preliminary*, a term we have used throughout our research.

And thus it is the concept or *principle* of aural adaptation which is important. It is that *approach* to the problem of aural learning which has been shown in this research effort to make a difference (in contrast to the traditional approach of trying to teach blind students to be "better listeners").

Future applications: improving upon the content of educational presentations.

The results of our work so far show that SOS research has the potential to develop into a technology for refining educational materials, not only in terms of their *structural properties* (e.g., an obvious extension of the benefits of recording material on two tape tracks would be to use four tracks and see how that works, and so on) but also in terms of *content*. For example, the aural learning laboratory could be used as a kind of *automatic editor* of content. Not that it would re-write material. We still need a human being for that! But it could certainly provide an objective basis for determining some places where editing is *needed*. That is possible because of the fact that *study activity data can provide crucial information about the efficiency of details of textual content*.

The development of an automatic editor rests upon our ability to define certain *study states* in terms of *study performance*. For the purposes of editing the content of educational text, we would be particularly interested in the study states of *confusion* and *comprehension*. That is, it would nice to know exactly *where* students are not understanding and *where* they do understand while they are studying an educational presentation.

This problem of identifying the textual sources of confusion has generally received very inadequate attention. The usual case is that a few people besides an author will read through an educational text and make suggestions for content alterations which *they* think will clarify the presentation. But, of course, *they* are not the students who must try to understand the content.

They are usually professionals who already understand the presentation. And their suggestions are more often than not of a *general* nature (e.g., to "alter the sequence" or "expand a bit upon this idea" or "you forgot to mention about" and so on).

But we have found that it is *details* of a presentation which are more often particularly troublesome to those engaged in independent study. It is not so much whether the explanation of an idea has been developed in an elegant fashion, / but rather what has been said in a given *sentance, a particular subordinate clause, or even a single word* which results in the study state of confusion. Words, for example, will often occur without any definition. The author either assumes the definition to be part of the students' repertoire of knowledge, or the omission is an oversight. Even technical words occur with no explanation of their meaning. It is details such as these that we have come to realize can cause several students to flounder around in confusion for the better part of one or more study sessions. And given the current state of the art of editing, such details are unlikely to be picked up.

How can this kind of problem be attacked with the research tool which we have developed for aural study analysis? Well, it can be done by identifying various characteristics of study performances which are manifistations of floundering around in confusion. And that is possible because when students are confused, they interact with study material in different ways than when they understand it. The best way to appreciate that point is for the reader to carry out the following introspective exercise.

Imagine that you are a student who is about to study some unfamiliar material which you want very much to understand (perhaps you will be tested on it in a day or so). You begin reading, and for the first three and one-half pages you encounter no serious problems of understanding. There are a few times when your attention drifts for a few seconds, but as soon as you realize that, you re-trace a few lines with your eyes and re-read. All is

well. As far as you are concerned, you understand what is being said. And there is a pattern of eye movements which has occurred during your reading of the three and one-half pages which typifies that fact.

Now imagine that you come to a paragraph that seriously confuses you. To begin with, it contains an awkward word construction embedded in a long sentance. And by the time that you reach the end of the paragraph, what you think it means contradicts what you have all along believed was the meaning of the previous pages. What might happen to your study performance in a hypothetical case like this? The following sequence of study activity events might occur:

1)Your reading stops for over a minute as you brood about the matter.

2)You re-read the paragraph and stop again to think about the fact that your point of confusion remains the same.

3)You return to that long, awkward sentance construction to make sure that your understanding of it is not the source of your problem. But that is no help.

4)You then read on past the troublesome paragraph, deciding that the matter may be cleared up in the succeeding paragraphs. But it isn't.

5)Your eyes return to the start of the confusing paragraph again, but you don't read it. Instead, there is a relatively long break in your study.

6)Finally, after deciding that you must have misunderstood an important point during your initial reading of the first three and one-half pages, you return to a section heading on page two and begin to read that section more slowly than you did the first time around.

7)And so on.

Now this sequence of study activity events is, of course, not what would necessarily occur. But that's not the point. What is important here is that your whole pattern of study has changed, and the change is centered around a specific detail of text (in this case, an entire paragraph). In our example,

if we had been monitoring your eye movements as you studied, it would be clear from the change in your study activity pattern (SAP) that the paragraph had caused you difficulty. And if you were one of 20 students we were monitoring, and 17 of them produced records which showed changes in the SAP's centered around that paragraph, that would provide us with an objective basis for editing the text appropriate to that verbal detail.

By the same token, when blind students study on tape recorders, they operate them within one general class of SAP's when they are comprehending what they are interacting with. When they don't understand, a different class of SAP's results. That is, students who are trying to understand what they are hearing simply do not operate the tape recorders in the same way when they become confused. Their pattern of study changes in recognizable ways. Thus it is quite possible to infer a study state (e.g. confusion) from a particular SAP which falls within a well-defined class. (Such classes can be arrived at through research where subjects report study states so that the monitoring computer can correlate them with SAP's.)

The data of Fig. 22 showing search-return cycles are a perfectly good illustration of the principle that study states may be inferred from the properties of a study performance. For example, pick one of the narrative cycles in Fig. 22. It is clear that a particular question from which the cycle originates has not been understood. The question is a particular one-sentance, verbal detail. The whole search-return cycle occurring in that study context (the fourth IS session) is a particular SAP, which falls within the definition of a class of SAP's (other examples of which are seen in Fig. 22). That is, the quantitative properties of such search-return cycles may be used to define a class of study activity patterns from which we may reliably inf er facts about a student's study state (in this instance, that the student does not understand the answer to questions).

Thus the principle of inferring study states from study performance has already been demonstrated in the data of Exp III and it has wide-ranging implications for education (as well as for research in the psychology of thinking). To return to our concept of an automatic editor, how might editing of the content of educational presentations be made automatic? Research would be necessary to define classes of SAP's which reliably reflect various study states of interest. We say "various states" because there are, first of all, SAP's which reflect various *kinds* and *degrees* of confusion. And there are other study states which are not related to confusion or comprehension which are also relevant to editing content.

As can be seen from the search-return cycles of Fig. 22, SAP's can be quite complex, and the problem of automatic detection of them would require a computer program which could discriminate the critical properties of one SAP class from another. The best way to understand the complex is to start out with the simple. The simplest kind of aural SAP is any sequence of two tape recorder responses, or what we will call a *response couplet*. Figure 27 shows the percent of response couplets for four paired response categories as a function of successive blocks of units for Subject #25 (Exp. III). As would be expected from the other graphs of the study performance of that subject, AS tapes control an entirely different relative distribution of response couplets than do LT tapes. Our purpose here is not to interpret the shapes of these distributions, but rather to show that the frequency distribution of even the simplest kind of SAP is highly sensitive to changes in experimental conditions. Figure 27 illustrates that the shape of the frequency distribution of response couplets is *itself* a study activity pattern -- one which we will call a *compound SAP*. Such compound SAP's can obviously be used to identify what study strategies a student is applying to his study, but they also may be useful in identifying the most prevalent study states during a period of study.

Figure Legend

Figure 27. Frequency distributions of the simplest kind of study activity pattern (SAP). The ordinate shows the percent of response couplets for four paired response categories as a function of successive blocks during Exp III. Blocks 1 and 3 (solid) are for the study of LT tapes. Blocks 2 and 4 (hatched) are for the study of AS tapes. Each of the four distributions is an example of a compound SAP. Data are from Subject #25.

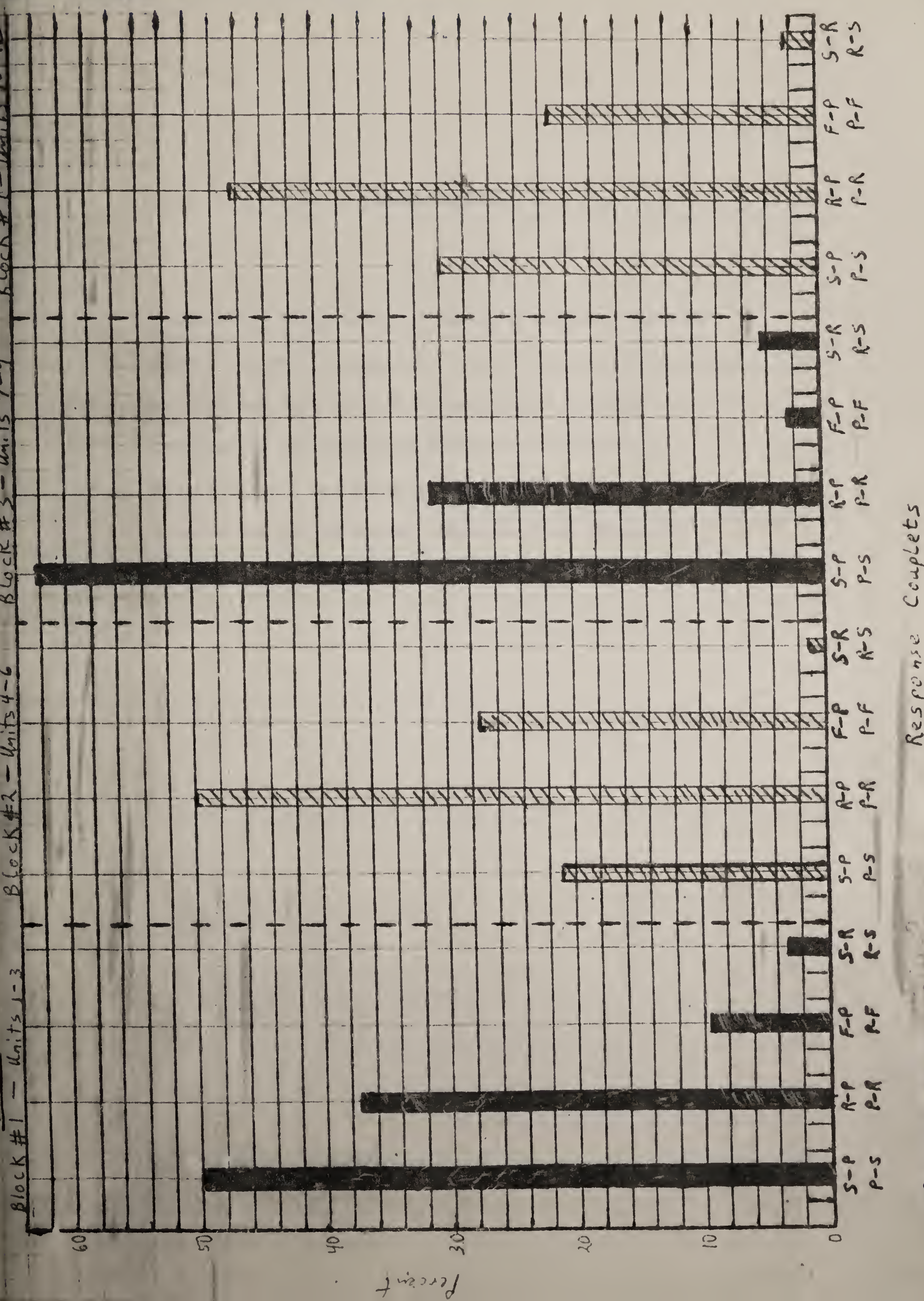
Block #1 - Units 1-3
Block #2 - Units 4-6
Block #3 - Units 7-9
Block #4 - Units 10-12
S-P P-S
R-P P-R
F-P P-F
S-R R-S
S-P P-S
R-P P-R
F-P P-F
S-R R-S
S-P P-S
R-P P-R
F-P P-F
S-R R-S
S-P P-S
R-P P-R
F-P P-F
S-R R-S
0
10
20
30
40
50
60
Percent
Response Couplets

FIGURE # 27

Figure Legend

Figure 28. The percent of response couplets for four paired response categories. Solid bars show IS sessions and hatched bars are for RS sessions. Response frequencies are indicated at the top of each bar. Blocks 1 and 3 are for the study of LT tapes. Blocks 2 and 4 are for AS tapes. Data are from Subject #25.

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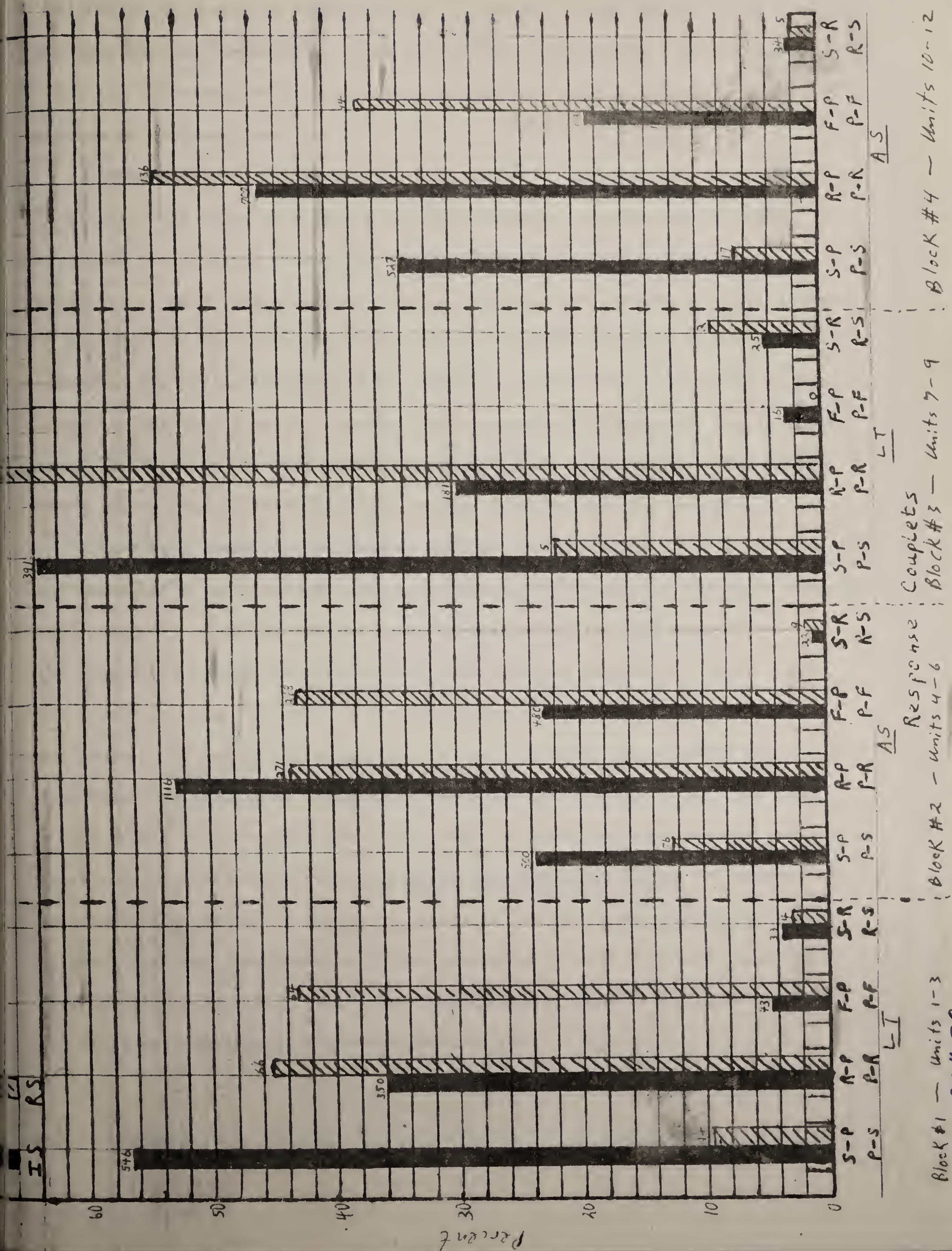

FIGURE # 28

Figure 28 shows the data from Fig. 27 for IS (solid) and RS (cross hatched) sessions separately. Here we see four identifiable compound SAP's which are the result of an interaction between two tape structures and the purpose of the study session.

These examples are the simplest kind of SAP's, and they are definable in quantitative terms such that a suitable computer program could reliably recognize the critical properties which differentiate them. The computer detection of more complex patterns (e.g., the relative frequency distributions of sequences of more than two responses, with certain temporal parameters included in the definitions) would be necessary to deal with the problem of the automatic editing of verbal details like paragraphs or sentances, but in theory, there is no reason why this cannot be accomplished. And certainly the simple SAP's can be used to identify study *trends*, like fatigue, for example.

Therefore, armed with a computer analysis program which is able to recognize different SAP's, we should be able to automatically obtain the objective information necessary to decide how and where to make selective improvements in the content of preliminary versions of tape recorded materials. There are other ways in which research on the relations between SAP's and study states can prove to be useful for education. A very important one concerns the measurement of individual differences which we will discuss below. But the reader should also consider how a knowledge of where confusion occurs, and how prevalent it is, can be used to *calibrate the difficulty levels* of educational materials with respect to groups of students. To the extent that study activity data are correlated with test scores, we should be able to use such data in all the ways that test score information is used, which leads us into our final anticipation for the SOS research tool.

Future applications: the measurement of individual differences between students.

From the above discussion, it is clear that SOS research is not limited to the improvement of educational materials for the blind. Sighted students also study by listening (e.g., with audio-visual programs); and further, if particulars of content are determined to be confusing during aural study, there is no reason at this point to not suspect them of being confusing during visual study. Thus the technology of editing content has a very general potential. It ought to apply equally well to materials developed for all levels of education.

Another area of SOS research which has potential application to student populations in general concerns the measurement of individual differences. If study activity data can be used to measure student confusion, then that kind of information can be used for all of the purposes for which test data are traditionally used, and with much greater success, we would predict. This is because the usual methods of testing fail to tap a great deal of what makes each student of unique academic ability. To illustrate that point, let us quote from the introduction to our previous funding proposal (submitted to the State Education Department, January 1981):

> "In our own work with visually impaired student/subjects, we often had the case that two or more of them would get nearly identical scores on tests after having studied the same tape. Ordinarily, one would assume from that that those students were fairly equivalent in learning ability and preparation (and, as teachers we might tend to treat them about the same). However, when we know some facts about how they studied those tapes, we are much less likely to arrive at that erroneous conclusion. Just knowing that one subject spent two hours and twenty minutes studying the tape, and a second student (with an identical exam score) spent eleven hours and forty minutes, will reveal to anyone that they are far from similar students in their ability and/or preparation.
>
> "But of course, with our SOS research tool, we know a great deal more about how our student/subjects studied. Our two identical scorers may also have very nearly equal study times, and yet their study data reveal substantial individual differences to us, for we know just how they distribute that time. For example, they listen at different tape speeds and spend disproportionate amounts

> of time on different concepts; they spend different percentages of time re-listening; one spends twice as long as the other in answering questions about what's been studied; one spends three hours and twenty-six minutes in reviewing the tape for a test, while the other spends only eighteen minutes. And when you look at the time each one spent in trying to answer questions which were, in fact, not answered correctly, you discover that they differ with respect to that datum by a factor of 2.8.
>
> "Thus, in knowing all that additional information about how they studied for and took the exam that they scored the same on, one tends to assign less weight to the exam scores as descriptors of individual differences in ability. In fact, the SOS research tool represents a potential new way of testing (ital. added) which is especially relevant to the area of educational remediation (e.g., in spite of identical exam scores, one student may need more help than another, or one may need a different kind of help from the other). So knowing something about how a student studies material puts the "SOS teacher" in a very priviledged position." (pp 3 -- 4).

There is no question that test scores are very well-correlated with certain combinations of properties of study performance, but determining those combinations will require more research. The analysis of study states in terms of SAP's is certainly part of what is needed to predict test score performance. We have not had the time (or the software development) to involve ourselves in this complex question, but we did make some scatter plots, seen in Fig. 29, showing that there are strong relationships between study activity variables and test scores.

The data of Fig. 29 are from Subject #25. They show correlations between test scores for six units and various measures of test-taking performance. (Note: the lines of best fit are merely visual estimates.) With further research, we feel sure that the conditions under which reliable correlations between study activity performance and test scores obtain can be much better understood. In that case, study performance itself can be used as a measure of comprehension (as supplementary to, or even in place of, traditional test data) with a wide range of possible applications. We have already mentioned the calibration of the difficulty levels of study materials, either for groups of students or for an individual student. As with other measures of comprehension, study activity

Figure Legend

Figure 29. Correlations between six measures of test-taking performances and unit evaluation scores for Units 7 -- 12. Data are from Subject #25.

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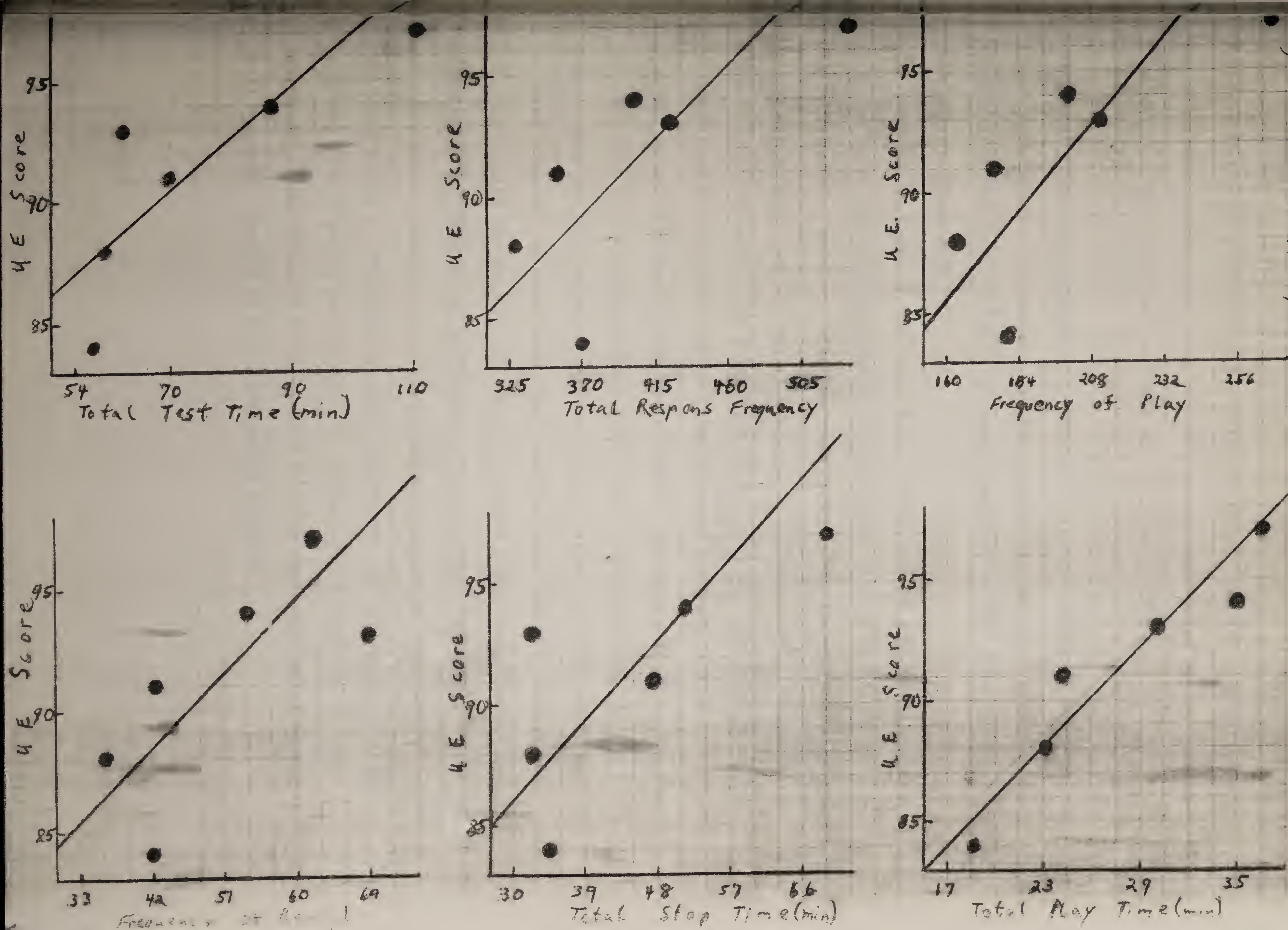

Fig. 19.

data can be used for prediction and classification. And the possibilities for using information about study activity performance as an aid in remediation efforts with individual students are very encouraging.

In conclusion, we feel that the research tool that we have developed on the *Learning Through Listening* project has a future, at least in the long run, if not immediately. The project has been truely innovative. We have not "re-invented the wheel" which is a common complaint we hear about research in education these days.

However, in spite of the large amount of support we have already received from the State Education Department, we still feel that it is incumbent upon that governmental agency to take the responsibility *to see that this information is now put to use*. And by "put to use", we do not mean merely dissemination. We mean acting in such a way that blind students in New York State can begin to benefit by studying from better tapes than those that are currently available to them. That is, we now know how to make better tapes. The next step is to see that they are made in the subject matter areas where they are needed. If the SED doesn't take the initiative in this matter, how else will it happen? And if it doesn't happen, we have spent five years and over $400,000 for nothing.

Our results are not trivial. *They represent a big break-through for the education of the blind -- at all levels -- both children and adults*. Even without any further research, it is clear that the adaptation structure -- in its preliminary form -- represents a great improvement over LT tapes. That improvement should now be put to use. It is time now to "cash in" on our laboratory accomplishments by developing AS tapes which will be of benefit to "real students" instead of just "laboratory subjects."

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VII APPENDIX

A. Table of Contents for the "Short" Version of the Ecology Course Used for Experiments I and III.

LEARNING THROUGH LISTENING PROJECT

Ecology Course Outline (revised 9/77)

Unit 1: Introduction to Ecology

"Long" Version	"Short" Version	
LS #1	LS #1:	Contents
LS #2	LS #2:	The Meaning of Ecology
	LS #3:	The Earth as an Ecosystem
LS #3	LS #4:	Some Considerations in Defining Ecosystems
	LS #5:	Resources, People, and Pollution in Ecosystems
LS #4	LS #6:	Summary

Unit 2: Food

LS #1: Contents
LS #2: Where Food Comes From
LS #3: Hunting, Gathering, and Farming: How People Get Food
LS #4: Modern Farming: Good and Bad
LS #5: How pesticides are Harmful
LS #6: Summary

Unit 3: Water

LS #1: Contents
LS #2: Where Water Comes From
LS #3: Too Many People and Not Enough Water
LS #4: Water Pollution From Human Wastes
LS #5: Water Pollution From Industry & Agriculture
LS #6: Summary

Unit 4: Air

LS #1: Contents
LS #2: Air, Weather, and Climate
LS #3: How Human Activities can Affect Climate
LS #4: What is Air Pollution?
LS #5: Some Effects of Air Pollution and What Can Be Done About Them
LS #6: Summary

. . . . continued

Ecology Course Outline - 9/77

Unit 5: Energy

LS #1: Contents
LS #2: What is Energy?
LS #3: Some Environmental Problems of Energy: Nonrenewable Sources
LS #4: More Energy Problems: Renewable Sources
LS #5: Ideas About Energy: Old and New
LS #6: Summary

Unit 6: Population

LS #1: Contents
LS #2: Some Basic Facts About Population Numbers
LS #3: How Population Grows: Births, Deaths, and the Law of Compound Growth
LS #4: More About Population Growth and Other Kinds of Population Patterns
LS #5: Why Population Patterns are Important, and What Can Be Done About Them
LS #6: Summary

Unit 7: Ecology Solutions: Biological Control of Pest Organisms

LS #1: Contents
LS #2: Biological Control of Pest Organisms: The Predator-Prey Method
LS #3: Biological Control of the Cereal-Leaf Beetle: the Parasite-Host Method
LS #4: Biological Control of the Screwworm: the Sterilization Method
LS #5: More About Biological Control Techniques
LS #6: Summary

Unit 8: Developing an Ecologically Aware Lifestyle

LS #1: Contents
LS #2: We Can Learn New Habits if We want To
LS #3: Ecology at Home: in the Kitchen
LS #4: More About Ecology in the Kitchen, Laundry Room, and Bathroom
LS #5: More About Ecology at Home: Family Planning and Other Ideas You Can Use

. . . .continued

Ecology Course Outline (revisions & continuations, 2/78)

Unit 9: Nutrition, the Ecology of Your Body

LS #1: Contents
LS #2: Introduction to Nutrition
LS #3: Proteins
LS #4: All About Fats
LS #5: Carbohydrates
LS #6: Summary

Unit 10: More About Nutrition

LS #1: Contents
LS #2: Vitamins
LS #3: Minerals
LS #4: Exercise, Nutrition, and Your Health
LS #5: Wake Up, America: What You Eat May Be Killing You
LS #6: Summary

Unit 11: Diet for a Small Planet

LS #1: Contents
LS #2: Proteins are a Limited Resource
LS #3: Feeding Protein to Animals Instead of to People
LS #4: Protein and the American Culture
LS #5: The American Diet and Ecological Solutions
LS #6: Summary

Unit 12: The Psychology of Ecology

LS #1: Contents
LS #2: The Consequences of Behavior
LS #3: Complex Consequences
LS #4: Unfavorable Conflicting Consequences
LS #5: Concludeing Remarks
LS #6: Summary

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